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QUARTERLY

OF THE

National Fire Protection Association

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National Fire Protection Association

INTERNATIONAL

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Western Insurance Bureau.
Western Sprinkled Risk Association.
West Virginia Fire Underwriters' Association.
West Virginia Inspection Bureau.
Wisconsin Inspection Bureau.

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Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

Tennessee Inspection Bureau.

Bridge across the Mississippi River at Memphis burned on Sept. 17, 1928, with a loss of over $200,000. This is the only vehicular bridge across the Mississippi River south of St. Louis, and the economic losses incident to the interruption of traffic are estimated equal to if not more than the direct fire loss. **(See report on page 182.)**

The Quarterly

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Fire Loss Trend Continues Downward. The total fire loss of the United States and Canada for the first nine months of 1928 was $226,461,000 according to the estimates of the New York *Journal of Commerce*. This compares with $247,341,400 for the same period last year and represents a reduction of approximately eight per cent. Unless the last quarter of the year registers losses much in excess of the same period for recent years, the year 1928 will show a still further improvement as compared with the previous twelve-month periods. It will be recalled that the year 1927 showed the first material reduction in fire losses that has been registered since 1919. The losses by months for 1925, 1926, 1927 and 1928 through September are reported by the *Journal of Commerce* as follows:

	1925	1926	1927	1928
January	$41,210,400	$41,118,750	$37,910,600	$43,260,800
February	32,472,000	30,963,750	26,285,000	41,105,400
March	33,346,500	42,854,600	26,807,600	30,377,000
April	37,696,800	52,408,400	39,720,600	25,980,600
May	29,170,800	32,764,200	20,713,000	23,202,000
June	23,650,800	28,676,000	25,481,200	11,123,000
July	29,622,000	31,723,400	24,248,600	17,106,400
August	23,348,750	27,833,400	24,299,800	17,123,000
September	25,396,250	19,309,000	21,875,000	17,182,800
Total 9 months	$275,914,300	$307,651,500	$247,341,400	$226,461,000
October	23,991,250	14,877,000	22,326,600	.....
November	30,320,000	26,724,400	18,992,200	.....
December	43,275,000	43,757,600	31,935,400	.....
Totals	$373,500,550	$393,010,500	$320,595,600	.....

These figures of the *Journal of Commerce* should not be confused with the statistics of the National Board of Fire Underwriters, which for the years given are as follows:

1925	1926	1927
$559,418,184	$560,548,624	$478,245,620

The figures of the *Journal of Commerce* are essentially newspaper estimates. The figures of the National Board of Fire Underwriters are based on insurance loss reports with a percentage added to cover unreported losses. While there is a material difference between the totals given in the two sets of figures, the general trend of the two is similar. The estimates of the *Journal of Commerce* are immediately available, whereas the statistics compiled by the National Board are not published until some months after the close of the year. Those making use of the above quoted loss figures for the first nine months of 1928 should keep in mind the relation between these and the National Board statistics.

An editorial in the January, 1928, QUARTERLY, commenting upon the 1927 fire losses, expressed the opinion that the decreased loss was largely due to fire prevention effort, but that such fire prevention effort was not as yet sufficiently general to justify any prediction that the downward fire loss trend would continue through 1928. The present decrease in the fire waste presumably results from the cumulative effect of fire prevention work over a period of years during which the absolute amount of the fire loss was annually increasing. Whatever may be the explanation of the present downward trend it should be generally accepted as an encouragement and stimulus to further fire prevention activity.

* * * * *

Fire Department Progress. A review of the program of the thirty-fifth annual convention of the Pacific Coast Association of Fire Chiefs (copy obtainable of Fire Chief M. J. Dunphy, Sacramento, Calif.) must inspire confidence that the fire departments of the country are now on the way to substituting scientific methods for rule-of-thumb, and collective wisdom and experience for individual personal notions. The Pacific Coast Association has always emphasized the value of fire department education. In this respect the New England Association of Fire Chiefs, comparatively of recent origin, also deserves mention. The Pacific Coast Association this year goes further than at any previous convention and features a fire prevention and protection lecture course, covering a range of subjects that a few years ago would have been considered beyond the range of a fireman's natural interest. There is a growing movement outside of the firemen's organizations to furnish educational opportunities to men in this service, exemplified by the courses of instruction given annually in connection with certain state universities, of which the University of Illinois is perhaps at present the most conspicuous example. The current program of the Pacific Coast Chiefs compares very favorably with those so far presented at the universities, and is of special interest because it is the result of awakening within rather than without the fire chiefs' organizations.

* * * * *

Out of the West. In view of the establishment of fire schools or "colleges" in quite a number of local fire departments in various sections of the country, it may not be fair to say that the impulse for improvement in fire departments and their practice came entirely from the West. And yet the influence of a western man, Jay W. Stevens, one time Battalion Chief in the Portland, Oregon, Fire Department, cannot be honestly ignored. Mr. Stevens, during and since his actual fire department employment, has held steadfastly to the belief that the fire service should strive to merit the high respect due to an acknowledged profession. While giving full credit to fire

extinguishing skill and ability, he believes that the fire chief should not only interest himself in fire prevention, but should make himself a leader in it. This belief, held by a man of generous instincts, lovable character and boundless energy, has already influenced many chiefs in the organizations with which Mr. Stevens is affiliated to see in their profession a new dignity, and they have enlisted under his leadership in an effort to raise the morale of fire department officers and men throughout the country. The National Board of Fire Underwriters in taking Mr. Stevens into its service as Chief of its Conservation Department has shown rare good judgment in attempting no abridgment of his activities among the fire chiefs. Becoming Secretary of the Pacific Coast Association, succeeding Harry Bringhurst, his energy and influence have promoted a remarkable growth of that organization, whose members, being also members of the International Association of Fire Chiefs, are now making progress in rejuvenating that body. Mr. Stevens, now Executive Secretary of the latter organization, was personally responsible for the production of the motion picture "The Fire Brigade," and has promoted the system of regional organization under which the international body of chiefs is now operating. He is no ordinary man whose faith and enthusiasm can cope undiscouraged with the problem of creating new ideals and new responsibilities in a profession many members of which for years have not been and are not yet too eager to keep abreast of scientific progress. If all of Mr. Stevens' plans should not meet with the high success he bespeaks for them, let him not lose heart. He is doing a man's job with fortitude and rare good nature, and few things in life are finer than that.

* * * * *

Children and Matches. "Children playing with matches" is an all too frequent cause of fire, particularly deplorable because of the large number of children annually burned to death or maimed for life. Despite continued warnings as to the danger of allowing children to play with matches, the fires and casualties from this cause continue. Fire prevention authorities have for years been admonishing parents to keep matches out of the hands of children, and school fire prevention programs have emphasized this danger. In this phase of fire prevention parents and teachers have given wholehearted coöperation. It has not been due to any lack of interest on the part of adults in charge of children that this particular cause of fire has not been eliminated. It may be that the lack of success in controlling this hazard is primarily due to a wrong method of attack based on an improper understanding of child psychology. This is indicated by Bertrand Russell, who says in an article in the *Outlook:*

> To a grown-up person it seems obviously undesirable that the house should burn down, but to a child this is by no means obvious. He thinks it would be a glorious blaze, and having to go elsewhere would be fun. Therefore if you appeal to him rationally and

say, "Do not drop matches in the waste-paper basket, because you may cause the house to burn down," you waste your breath. Nor is it desirable, except with very young children, to keep matches out of their way, for sooner or later they are sure to come across them with a desire stimulated by prohibition. The only safe way is to allow the activity, but under controlled conditions.

Mr. Russell's thought seems reasonable, but in applying it there is likely to be a difference of opinion as to the "controlled conditions" under which children might be allowed to use matches. He goes on in the article to suggest outdoor bonfires, where children may become interested in the kind of skill required for the purpose. This seems questionable advice, for it is only under special conditions that even adults may kindle bonfires with full safety.

Where children are allowed to have a regular share in the ordinary routine of household duties, Mr. Russell's precepts may be carried out by permitting children to use matches—always in the presence of adults—for the usual domestic purposes for which matches are employed. And if in addition to the elimination, by means of familiarity, of the "forbidden fruit" desire, the child learns something of the properties of fire through the experience of a burned finger, the "cure" should be even more effective.

* * * * *

Film Exchange Fire Record. The Motion Picture Producers and Distributors of America (Member N.F.P.A.) is the organization of those in charge of the manufacture and distribution of films throughout the country. The storage and handling of motion picture film of the nitrocellulose variety constitutes a severe fire hazard unless careful attention is given to fire safety precautions, as indicated in the regulations of this Association on this subject. A few years ago the fire record of film exchanges was notoriously bad. A fire safety program was put into effect. Fire-resistive film exchange buildings were constructed and a continuous program of fire prevention education was carried on. The details of this work and the resulting improvement in the fire record have been reported from year to year by the Motion Picture Producers and Distributors of America at the annual meetings of the N.F.P.A.

Interesting information on the results of this program is given in the following letter from Mr. A. S. Dickinson, Director of the Conservation Department of the Motion Picture Producers and Distributors of America:

On Wednesday, August 15, 1928, there occurred for the first time since January, 1927, a fire in one of the exchanges which had been receiving the benefits of our safty-conservation work.

This fire happened in the inspection room of the Pathé New York Exchange. An investigation discloses the following facts:

The inspection room is on the fifth floor and is on the east side of the building, therefore is exposed to the sun's rays in the forenoon. On the day of the fire one inspection table was not used until about 10:30 A.M. An inspectress then sat at that table and started to mount a film which had just been received from the laboratory. Apparently the film

was lying on the flat surface of the table while it was being wound. Without warning, the film suddenly blazed up, caused undoubtedly by friction and heat.

The exchange suffered a monetary loss of only $25.00. The significant part about this fire was that everybody knew just what to do. The entire floor was vacated speedily and with order, which accounts for the fact that no one was injured in any respect. Also only one reel of film was exposed at a time, so that was the extent of the damage.

The exchange had complied fully with the requirements of the Safety Department of the Motion Picture Producers and Distributors of America, Inc., otherwise more serious results might have occurred that could not be measured in terms of dollars.

The motion picture industry is indeed to be congratulated on the record reflected in Mr. Dickinson's letter. It should be noted, however, that the fire safety program referred to does not cover all of the establishments handling motion picture film; there is a minority outside of the organization where proper attention apparently has not been given to the obvious hazard involved. Convincing evidence of this is furnished by the report of a film fire in Kansas City, Mo., published on another page of this QUARTERLY. The contrast between this fire and the fire reported by Mr. Dickinson is striking.

* * * * *

The Burning Hill.*

By Abbie Huston Evans.

The Burning Hill, they call it. Long ago,
A generation since, the coal took fire;
Men fought the flame awhile, but came to know
It ate too deep and crept too slow to tire.

Sometimes at night men wandering on the hill
See small blue-pointed flames play through a crack,
And know the ancient fire is gnawing still
At the hill's core, red eating up the black.

Yet some day will the last black inch be ash
In the last alley burrowing underground,
And the whole hill stand full of clinkered trash,
A burned-out furnace, one great cinder-mound.

—Oh what of buried fires that show no spark,
Burning away a life-time in the dark?

*From *Outcrop*, by Abbie Huston Evans. By special permission of Harper & Bros., publishers.

Executive Committee Action.

The Executive Committee has approved by letter ballot minor changes in two Regulations in order to permit immediate printing of new editions incorporating the revisions recommended by the technical committees having jurisdiction.

Committee on Hazardous Chemicals and Explosives.

In accordance with the recommendations of the committee, the following changes were approved in the Regulations on the Storage, Handling and Use of Pyroxylin Plastic in Factories Making Articles Therefrom. These changes are in addition to those adopted at the 1928 annual meeting (Proceedings, 1928, page 184).

Change the title of Section 47 to "Dipping, Spraying and Cementing."

Change Section 47 (a) to read: "Cementing of joints and other extensive cementing processes where considerable flammable cement is used, also dipping and spraying, shall be done in well-ventilated rooms devoted exclusively to such work and separated from the remainder of the building by vapor-tight walls or partitions, constructed in accordance with Section 16 of these regulations."

Committee on Flammable Liquids.

In accordance with the recommendations of the committee, the following change was approved in the Regulations for the Installation of Oil Burning Equipments where a Competent Attendant Is Not Constantly on Duty in the Room Where the Oil Is Burned, and for the Storage and Use of Oil Fuels in Connection Therewith (Domestic Oil Burner Regulations).

Revise Rule 1 (b) to read as follows: "When located inside the building the aggregate capacity of the tanks used in connection with the system shall not exceed 275 gallons, unless the amount over and above 275 gallons is installed and protected in accordance with the provisions of Rules 14 and 21 of the preceding regulations for oil burning equipments other than domestic.

"When located outside above ground the provisions of Sections 9 to 13 inclusive and Section 18 of the preceding regulations for oil burning equipments other than domestic shall be complied with."

Note: For convenient reference the numbering and titles referred to are those of the 1925 edition. These will be changed in the 1928 edition, but with no modification of intent.

Why Milwaukee Won.

There are two ways of winning a race. One is by a brilliant burst of speed at the end, the other by a steadily increasing pace from the beginning. The first has in it the element of chance; the second is the surer way, bearing promise of further victories. It was in the latter fashion that Milwaukee in 1926 won first prize in the fire waste contest conducted by the Chamber of Commerce of the U. S.

In order to dazzle and surprise by a spectacular reduction of its fire waste a city must have a pretty bad record at the beginning. Milwaukee has always enjoyed a relatively low fire loss. Her heaviest loss occurred in 1921 when a large factory burned, due to a twenty-minute delay in transmitting the alarm. The loss per capita in 1921 was $5.55. In 1927, according to the National Board of Fire Underwriters, it was $1.98.

Milwaukee was settled and developed by a prudent people who believed and yet believe that there are few phases of industrial good business that represent a greater asset than a *good fire record.* In 1921 the Association of Commerce organized a Fire Prevention Committee of twelve men. This committee has met once a week ever since, except in midsummer.

The fire prevention committee for the first two or three years of its life carried on the usual educational activities followed by other progressive cities, promoting public fire prevention activities and sponsoring annual fire prevention week programs. But it felt the need of an intenser attack and found a point of departure in a study of the fire records of the fire department, how and where fires started, and how they were spread or extinguished. From a review of these facts and figures it appeared that the Milwaukee fire department was not receiving the coöperation from industry it seemed reasonable to expect. First, there was the watchman. The watchman might be competent to chase prowlers off the premises, but did he know just what to do when he discovered a fire? The study of the fire reports proved that he did not. The watchmen of our industries should be instructed, the committee concluded, and a school for this purpose was begun in 1924 with the watchmen from fifty establishments. The first year developed the fact that it was not the watchmen alone who needed educating; so also did the foremen, and superintendents, and managers. It was all right to speed up production, but how about safeguarding production? A fire would not only slow production up, it might stop it for a time altogether. In fact that is exactly what was happening quite regularly. "Let us get into our industries a fire prevention consciousness," said the committee, "so that Milwaukee's production shall not be impeded at any point by pre-

ventable fires." To accomplish this the watchmen's school was developed into a fire prevention school. The amazing success of this project is indicated by the enrollment, which was as follows:

Milwaukee Fire Prevention School.

Year	Companies Co-operating	Individuals Receiving Instruction
1924	50	223
1925	126	1,230
1926	128	1,556
1927	132	1,588

It is interesting that as the school progressed the fire loss decreased and the average amount of loss per fire diminished, indicating not only better care of property within the industries, but a prompter calling of the fire department, resulting in fire extinguishment with smaller loss. It is reasonable to conclude that the special fire hazards of Milwaukee factories are coming to be understood by the men who are nearest to them when fires start. Following are the figures taken from the fire department records corrected to conform to the proof of loss required to be filed with the department by insurance adjusters.

Year	Population	Loss	Loss per Fire	Loss per Capita
1923	480,000	$1,940,064	$856	$4.04
1924	492,087	1,485,949	632	3.02
1925	503,341	1,607,764	630	3.19
1926	520,000	1,512,084	539	2.90
1927	574,435	1,134,633	376	1.98

A substantial decrease in losses was scored in 1927 despite an increase of 54,000 in population.

In its general public education Milwaukee has used the most effective methods followed by other cities and developed certain methods of her own. One hundred thousand home inspection blanks are distributed annually to the pupils of the public and parochial schools. A number of firemen have been specially trained in the art of public speaking and give regular instruction to the schools, social centers and civic groups.

The fire department, the special agency maintained by the city for its public safety, realizes in Milwaukee its full responsibility, expressing through its capable and devoted chief officer a spirit of coöperation that extends and intensifies the educational efforts of the Association of Commerce. The fire department's educational work both precedes and follows its fire extinguishing operations, for every week the Fire Prevention Bureau gives, through the local broadcasting station, a review of the fires that occur, their causes and effects. Newspapers too frequently give but the spectacular features of fires, missing their educational value. The weekly radio talks of the Milwaukee Fire Prevention Bureau are educating and stimulating all of Wisconsin to protect its lives and property from fire. The drill school of the department is alert in its

study and adoption of new fire fighting methods, and has given the results of its training and knowledge freely to other Wisconsin towns and cities.

It is perhaps unnecessary to state that the development of the fire extinguishing facilities of the Milwaukee fire department has not been neglected while the city has been growing in population and the above educational efforts have been expanding. Since the issuance of the report of the National Board of Fire Underwriters in 1920, the number of pumping engines in service has been increased from 27 to 36, ladder trucks from 11 to 14, squads from 1 to 2, district chiefs from 7 to 10, fire stations from 33 to 38, and the total personnel of the fire department from 579 to 776.

Considerable improvement has also been made in the waterworks system, the total miles of pipe having been increased from 545.84 in 1920 to 738.65 in January, 1928. The number of fire hydrants has been increased from 3,784 in July, 1920, to 5,388 in January, 1928. A large quantity of large sized pipe has been installed, and a new pumping station and intake system has been built and is now in operation. This year the water department will lay approximately 50 miles of pipe and install 750 new hydrants.

As is invariably the case where the fire consciousness of a city has been successfully awakened, we see in Milwaukee the desired coöperation between the fire and water and building departments, coöperation so vital to continued fire safety, but which is woefully lacking in many cities of the country. Ordinances have been enacted governing the use of flammable liquids, regulating the storage of automobiles in the basements of office and apartment buildings, requiring the installation of standpipes in the higher buildings and regulating other practices and hazards having a bearing on the city's fire safety.

The rapid pace of modern life and the amazing extension of the use of natural forces will increase rather than lessen the hazards of every sort that confront the men charged with a city's well being. Milwaukee is to be congratulated upon her favorable fire record in the past. To this she is now adding a promise of the permanent maintenance of conditions that will attract to her borders those seeking to establish industries for which they desire an uninterrupted progress. The time is rapidly passing when cities which are indifferent to the community's fire safety can successfully beckon to new manufacturing enterprises. Milwaukee is alive and alert, and her steady and rapid growth in population has other explanations besides the fact that she has a pleasant location on the shores of a beautiful lake.

Gasoline Explosion Wrecks Home.

Firemans' Fund Record,
(Member N.F.P.A.).

The photographs on the opposite page are convincing evidence of the destructive power of gasoline. These pictures show the wreckage of the home of Mr. Lawrence Brooks at Salt Lake City, which was practically destroyed by an explosion on Sunday, May 13, 1928.

It is reported that Mr. Brooks was cleaning curtains or draperies in high test gasoline in a small washboiler in the basement. There was no furnace or open flame of any character in the basement and there was apparently no opportunity for the ignition of the fumes. Mr. Brooks thought that he was perfectly safe.

While stirring the gasoline and curtains in the tub with a stick, there was a sudden flash and a deafening explosion which threw Mr. Brooks to the floor, blew out three of the four side walls of the house, demolished the chimneys and wrecked a rear porch. Mr. Brooks was severely burned about the neck, chest, hands and arms, but was not fatally injured. Other members of the family in the house at the time, including his wife, child, and mother, fortunately escaped serious injury.

This explosion was not followed by fire, as has been the case following the usual gasoline vapor explosion of this type. A typical case of this character was reported in the QUARTERLY for October, 1927 (Vol. 21, No. 2, p. 119), where three people were killed and four injured in Toronto under somewhat similar conditions. In the Toronto case, however, fire closely followed the explosion, and it appeared that it was the fire rather than the explosion which was the major factor in causing the loss of life.

The cause of this explosion has not been definitely determined. It may have been due to a spark of static electricity induced by the stirring or agitating of the fabric in the gasoline washing process, or gasoline fumes may have penetrated to the kitchen above and come in contact with an open flame in the kitchen range.

The upper left-hand picture on the opposite page gives a close-up view of the east side of the house, showing the wreckage of the chimney in the foreground. It is interesting to note that despite the destructive effects of the explosion the glass in the kitchen cabinet remained intact. The upper right-hand picture is another view of the same side of the house, showing what happened to the chimney. The lower left-hand picture shows the back porch, and the lower right the kitchen.

Views of a house wrecked by gasoline explosion at Salt Lake City. Gasoline was used for cleaning curtains in the basement, with the results shown above.

The National Electrical Code.

Its Origin and Development.

The amazing development in the application of electricity to the uses of modern life, and the proverbial thoughtlessness of the American people in handling this not too well understood form of energy, have placed no light burden of responsibility upon those charged with the safeguarding of public safety. There are few more striking examples of the value of forethought than that illustrated by the origin and development of the National Electrical Code. By initiating proper regulation of electrical installations in buildings at the time when the wiring for electric power and light was in its earliest stages of development, the little group of fire insurance engineers first composing the Underwriters International Electric Association rendered a service to the underwriters, the electrical industry and to North America far greater than could possibly have been foreseen by anyone at that time. By the intelligent activity of this body an agency was created which has kept in step with the progress of electrical construction and practice through the past thirty-five years, guiding it along channels of safety to both property and life. Upon the foundation of safety laid by these men the electrical industry has willingly built its vast fabric of complicated business, in recent years coöperating actively not only in the frequent revisions of the Code, but in the efforts to secure its general recognition and observance put forth by the electrical field engineers of the N.F.P.A.

Two outstanding figures of the group which first projected a safety code for electrical wiring were Mr. C. M. Goddard and Mr. F. E. Cabot, both of Boston, and both of whom were subsequently active in the affairs of the N.F.P.A., Mr. Goddard being president during the years 1908-1910 and initiating a number of the important policies which now govern the Association.

No one living is more competent than Mr. Goddard to state the facts regarding the genesis of the National Electrical Code of which he himself was so distinguished a progenitor. The following letter from him constitutes a very valuable record of the beginnings of this project which is now of such paramount importance to both industry and life.

HOTEL BEACONSFIELD
BROOKLINE, MASS.

Mr. Franklin H. Wentworth, Managing Director, August 25, 1928.
National Fire Protection Association.

My Dear Wentworth:

I notice in the "Proceedings" of the last annual meeting of the N.F.P.A. that there appears to be a suggestion that the "Electrical Committee," which took the first steps in formulating a uniform code of rules for safe electric wiring, was organized, and the work on such rules begun, at a meeting held in Chicago in 1893.

As a matter of fact the first meeting, which was an informal one, was held in New York City on August 18, 1892, a full year before the Chicago meeting, and a set of proposed rules was then drafted.

An adjourned meeting was held in New York in December, 1892, at which Articles of Association were adopted for the permanent organization of the Underwriters' International Electric Association, the usual officers including an Executive Committee and an Electrical Committee were chosen. At this meeting there were present representatives of underwriters' boards from the United States as far west as San Francisco, and south as New Orleans, also from Canada.

The Electrical Committee took the rules as proposed by the August meeting, revised and amplified them, and the result was printed and distributed as the "Rules of the Underwriters' International Electric Association" on March 20, 1893, and they had been adopted and put into use by some fifteen insurance boards at the time the Chicago meeting, above referred to, was held on August 17, 1893.

As these rules, now known as the "National Electrical Code," are sponsored by the N.F.P.A., it would seem that it might be well to have in the N.F.P.A. files authentic information of the early history of the "Code" previous to 1911, when it was taken over by the N.F.P.A., and since which time its history is a part of the Association records. I am therefore adding a very brief "chronology" of the "Code" during that period.

1892.

May 3rd.—The secretary of the New England Insurance Exchange wrote to the insurance electricians in the Eastern, Middle, and South Atlantic states, suggesting the holding of a conference on the subject of electrical rules. (See Appendix "A.")

August 18th-20th.—Conference held in New York City, at which: 1st, a set of "Proposed Safe Wiring Rules" was drafted; and 2nd, it was decided to send a copy of these rules to insurance electricians throughout the United States and in Canada, and to call a meeting in December in New York City for permanent organization and for further consideration of the rules.

December 6th.—At the meeting resulting from the above call there were present insurance representatives from the United States as far west as San Francisco, and south as New Orleans, also several from Canada. Articles of Association were adopted organizing the "Underwriters' International Electric Association," and the usual officers, including an Executive Committee and an Electrical Committee, were elected. (See Appendix "B.") The proposed rules were carefully revised and it was voted that each representative would use his best efforts to have them promptly adopted by the organization which he represented.

1893.

March 20th.—The rules resulting from the December, 1892, meeting were sent out in print as the "Rules of the Underwriters' International Electric Association." These rules had been submitted in proof form to some of the leading electrical interests and had been highly commended. (See Appendix "C.")

August 17th.—At a special meeting of the Electrical Committee in Chicago, the secretary reported that the rules had already been adopted and put into use by a number of the principal underwriters' boards. At this meeting further revisions were made.

September 5th.—The Electrical Committee held another special meeting in Boston, going over the proofs of the rules as revised at Chicago.

October 1st.—A revised edition of the rules was promulgated.

December.—The annual meeting of the Electrical Committee was held in New York, careful consideration was given to the October rules, such revisions being made as experience indicated necessary.

1894.

June 15th.—The secretary issued a bulletin advising members that the rules had now been adopted by *all* the stock underwriting organizations.

July 1st.—An edition of the rules was promulgated based on the results of the December, 1893, meeting.

August.—The rules, with a few modifications, were adopted by the Associated Factory Mutuals, whose representative had been added to the committee soon after its organization.

December.—At the annual meeting of the committee the National Board of Fire Underwriters agreed to assume sponsorship of the rules, and the name of the association was changed to the "Underwriters' *National* Electric Association." The National Board also agreed to print the rules for the various boards, thus doing away with the opportunity to make changes in the rules, as had occurred in some instances where the printing had been done by the individual boards.

1895.

January 1st.—The rules resulting from the December, 1894, meeting were promulgated as the "Rules of the National Board of Fire Underwriters as recommended by the Underwriters' National Electric Association."

October.—A circular letter was sent out by the Electrical Committee and published in the electrical papers asking for suggestions for consideration at the December meeting and cordially inviting all who were interested in the rules, whether connected with the insurance business or not, to attend the meeting with the understanding that they would be accorded equal rights with the committee members as to discussion on the floor and also the right to *vote* on all questions which came before the meeting.

December.—The annual meeting was held in New York with fully 150 present in response to the above invitation, and from this time the large electrical interests took active part in the work on the rules.

1896.

January 1st.—Rules as revised at the December, 1895, meeting were promulgated.

During the year 1896, at the initiative of the National Electric Light Association, the National Conference on Standard Electrical Rules, which was composed of delegates from various national associations directly or indirectly interested in safe wiring, made a careful study of the existing rules and, through its representative from the National Board, sent certain recommendations to the Electrical Committee.

December.—At this annual meeting of the committee the recommendations from the national conference and other sources were considered and acted upon.

1897.

In the early part of the year various conferences were held, the rules were recodified by the committee, and the resulting code was accepted by the national conference. The name "National Electrical Code" was also adopted.

July.—The first edition of the rules of the National Board of Fire Underwriters under the name of the "National Electrical Code" was distributed, containing on the inside of the cover the names of the various national associations which had given them their approval and this form of publication, as well as the open forum nature of the annual meetings of the Electrical Committee for yearly revisions of the "Code" was continued up to the time when in—

1911.

The Electrical Committee of the Underwriters' National Electric Association, at its own request, was made a part of the National Protection Association, under whose

sponsorship it has since functioned, with its activities a part of the records of the Association.

Very truly yours,

C. M. GODDARD.

Appendix "A."

(COPY)

NEW ENGLAND INSURANCE EXCHANGE.

Boston, May 3, 1892.

Dear Sir:

Mr. F. E. Cabot, of the Boston Board of Underwriters, and myself, after talking over the matter, have thought it might be an advantage to the various Underwriters' Associations in connection with the matter of electrical rules and inspections, if the various inspectors would meet together and discuss the subject.

Will you kindly advise me if it would be probable that you would attend a meeting, say in the vicinity of New York City some time this summer.

I would be pleased if you would make any suggestions as to the time and place of the meeting. Also if you would suggest any inspectors whom you would desire invited in addition to the following list:

W. A. Anderson of the New York Board of Fire Underwriters; Wm. McDevitt of the Philadelphia Board; A. E. Bradell of the Middle Dept.; J. W. Churchill of the Southeastern Tariff Assn.; H. G. Balkam of the Baltimore Assn.; Rob't H. McNath of the St. Louis Board; W. E. J. Deming of the Minneapolis Board; Frank Kitton of the Buffalo Assn.; E. A. Fitzgerald of the New York State Assn.; and F. E. Cabot of the Boston Board.

Yours very truly,

C. M. GODDARD, Sec'y.

Appendix "B."

Members of the original "Electrical Committee" elected at the meeting in New York City on December 6, 1892, at which meeting the Underwriters' National Electric Association was organized.

FIRST ELECTRICAL COMMITTEE.

F. E. Cabot, Chairman, Boston Board of Fire Underwriters.
C. M. Goddard, Secretary, New England Insurance Exchange.
W. A. Anderson, New York Board of Fire Underwriters.
C. E. Bliven, The "Union" and Chicago Board.
E. A. Fitzgerald, Underwriters' Assn. of N. Y. State.
George P. Low, Pacific Insurance Union.
Edward Leloup, Southeastern Tariff Association.
William McDevitt, Philadelphia Fire Underwriters' Assn.
A. E. Van Geisen, New York Board of Fire Underwriters.

Appendix "C."

Copy of enclosure in letter received from Vice-President Bowker of the New York Edison Co.

THE EDISON ELECTRIC ILLUMINATING CO. OF NEW YORK.

March 30, 1893.

Mr. R. R. Bowker,
1st Vice-President.

Dear Sir:

Pursuant to your request we have gone over the proofs of the wiring rules proposed by the National Association of Underwriters, and beg to submit herewith our notes and criticisms.

These rules in general are far in advance of any heretofore proposed—so far as we are aware—either here or abroad. They treat very broadly the various electrical systems in use and will undoubtedly tend to raise the standard of electrical work in general.

Respectfully submitted,

J. VAN VLEET,
Chief Electrican and Consulting Engr.
ARTHUR WILLIAMS,
General Inspector.

An Unusual Experience with Safety Matches.

By D. H. Livingston,
Fall River Gas Works Co. (Member N.F.P.A.).

On Sunday, September 16, 1928, the writer had a peculiar and somewhat puzzling experience in which a box of so-called "Safety Matches" figured, as did an almost brand new suit of clothes, with slight damage to the latter.

I had been making a short visit at a hospital in Providence and on leaving was handing Mrs. Livingston into my automobile and had just closed the door, when I noticed a light reflected on the ground, and as this incident occurred after darkness fell, the light was quite bright. On looking down for the cause I noticed smoke coming from underneath my suit coat beneath the pocket, and heard a hissing noise as if a whole box of matches was burning. Knowing that that pocket contained a box of "safety matches," I immediately put my hand in the pocket of the coat and yanked the contents out. The inside lining of the coat pocket was burned and a small hole was also burned through the outside of the coat and through my trousers at that point.

On examination of the box of matches I discovered that not one of the matches had been burned, but a space covering half the side, where matches had been struck, was burned.

My theory of the accident is as follows: While fishing that morning the same box of matches was used for lighting cigarettes, and due to the fact that the box became damp it was necessary to strike a match against it several times before it ignited, and in this manner I believe some of the material from the match head became mixed with the material on the box. The box and material later dried out, and probably a blow was struck the box when the automobile door was being closed, with resultant ignition of the mixture on the outside of the box.

Carbon Dioxide Fire Protection.

By Robert S. Moulton,
Technical Secretary, N.F.P.A.

The use of carbon dioxide for fire extinguishing is not new, and the general principles of its application have been known for some years, but it is only recently that this method of fire protection for industrial hazards has been generally recognized. As yet carbon dioxide has not been in use for fire protection a sufficiently long period to build up a record of fire experience as a basis of judging its efficiency under varying conditions. What little fire experience that is available seems to be favorable, but thus far it has been necessary to rely largely on test data and theoretical considerations in forming conclusions as to the applicability of this form of protection for any given hazard under consideration.

A comprehensive article giving the theory and the history of the use of carbon dioxide in fire protection up to that time appeared in the *Quarterly* for October, 1924, in an article by C. L. Jones entitled "Carbon Dioxide in Fire Extinguishing" (Q. v. 18, No. 2, p. 145). The present article draws some details from the previous article and covers the more important developments since 1924.

Carbon dioxide acts in fire extinguishing primarily by reason of its smothering action in displacing or diluting the air to a point where the oxygen content is below that necessary to maintain combustion. There is also a marked cooling effect where the carbon dioxide is applied in the form of snow, but this is considered a secondary factor in the extinguishing action. Carbon dioxide has the advantage over other methods of fire extinguishing that it does no damage to the buildings or contents, thus eliminating the damage from water or chemicals that frequently is a high percentage of the total damage due to fire, especially in occupancies with valuable contents particularly susceptible to water damage. Where carbon dioxide is the sole extinguishing medium, the damage due to fire is solely that of what is actually burned; no unburned material is affected in any way by the carbon dioxide.

Carbon dioxide has many advantages, but also certain definite limitations which will be discussed in detail later. This form of protection is highly specialized, and in its present stage of development is not in general to be considered a substitute for older fire extinguishing methods, but rather a method primarily applicable to special types of hazards. Carbon dioxide extinguishment is still in an early stage of its development. Rapid progress is being made in the technique of its application, but as yet the details have been worked out for only a few of the many types of situations where it may eventually be found applicable.

Principal Uses of Carbon Dioxide in Fire Extinguishing.

Carbon dioxide extinguishing systems have been in successful use on shipboard for a number of years, and it was largely the experience thus gained that led to the development of its use in land applications. The limits of this article do not permit any discussion of the marine use of carbon dioxide, nor its use on mine fires, which latter subject has been covered in a previous *Quarterly* article (Vol. 17, No. 1, p. 42). Another large but little developed field for the use of carbon dioxide lies in the prevention of fire or explosion in hazardous equipment by continually maintaining an atmosphere of inert gas within the apparatus; this subject is likewise outside the scope of the present article.

The principal applications of carbon dioxide fire protection to date are in electrical equipment, and in hazardous manufacturing processes using flammable liquids. The use of this form of protection for fur vaults and record vaults is a still newer development. As in the case of other forms of fire protection, either hand extinguishers or permanent piped systems may be used, depending upon the extent and character of the hazard. Likewise, this form of protection may be arranged for either manual or automatic operation, after the manner of other means of fire protection in common use.

Characteristics of Carbon Dioxide.

Carbon dioxide, otherwise known as carbonic acid gas, with chemical formula CO_2, is a product of combustion or oxidation of all carbonaceous matter, and is normally present in a small percentage in the atmosphere. Commercially it is principally obtained from the combustion of coke under controlled conditions. For convenience in storage and shipping the gas is compressed to a pressure of from 700 to 1,000 lbs. per square inch (pressure varies with temperature), and handled in steel cylinders designated I.C.C. 3 (Interstate Commerce Commission). These cylinders are designed with a good factor of safety and provided with safety discs designed to open at about 2,400 lbs. pressure.

When compressed in the cylinders the gas is largely liquefied; this is an important factor in its use for fire protection, as will be brought out later.

Carbon dioxide gas is used for charging carbonated beverages served at soda fountains. It is thus a commodity already in common use and generally available at moderate expense.

Life Hazard.

One factor which has perhaps retarded the introduction of carbon dioxide fire protection is a popular misapprehension as to the properties of the gas from the viewpoint of life safety. This probably arises from confusion between carbon monoxide (CO) and carbon dioxide (CO_2). Carbon monoxide is the much advertised poisonous constituent of automobile exhaust gases and is rightly feared. This, despite the similarity of the name and

Factory Mutual Record.

A carbon dioxide hand extinguisher used on a test fire in an electric motor. The "smoke" is finely divided carbon dioxide snow which has a temperature of —110° F. The insert at the upper left shows the motor after the fire was extinguished. White patches are carbon dioxide snow.

chemical formula, has no relation whatsoever to the properties of carbon dioxide, which is absolutely harmless to life except as it may reduce the oxygen content of the air below that necessary for breathing, and it is said that no harm or discomfort results from breathing an atmosphere of maximum CO_2 concentration for a short period of time. It has been demonstrated by the experience of entombed miners that a smaller proportion of oxygen in the air is necessary to support human life than is necessary to support the flame of combustion of ordinary materials and that it is possible to live in an atmosphere so reduced in oxygen content that a match will not burn.* In any event the effect of carbon dioxide on the atmosphere seems negligible in comparison with that of the fire itself which generates irrespirable gases in large quantity. The burning of one pound of wood generates approximately 1.8 lbs. of carbon dioxide. A calculation based on average density and composition of wood shows that a piece of yellow pine 10 in. wide, 18 in. long and 1 in. thick generates in burning as much carbon dioxide as is contained in a 7 lb. portable carbon dioxide extinguisher.

It may be safely assumed that there is no life hazard involved in the use of carbon dioxide portable extinguishers in open rooms, or in the operation of fixed systems protecting individual dip tanks, dry cleaning washers or the like. The characteristic noise and appearance of the discharge are such that there seems to be small likelihood of anyone being unknowingly enveloped by the

*Quarterly, Vol. 16, No. 3, p. 239.

gas. However, where the gas is applied to flood an entire room or area the space should be evacuated before the CO_2 is introduced, and for such flooding systems alarm bells may be used in connection with the system to warn the occupants.

Instantaneous Operation.

Carbon dioxide, stored in cylinders under high pressure, when released expands almost instantaneously to from 400 to 500 times its original volume, producing under average conditions approximately nine cubic feet of gas per pound of cylinder content. When supplied through properly designed equipment, it produces an inert atmosphere in the space protected within a very few seconds. Its action is much quicker than other fire extinguishing methods; this is a decided advantage in the case of fixed installations, but in the case of hand extinguishers the relatively short discharge period tends to limit the effectiveness of the device when in the hands of persons not trained in its use.

Smothering Action.

Normal air contains about 21% oxygen; the addition of an inert gas such as carbon dioxide reduces the percentage of oxygen. When diluted with a sufficient proportion of carbon dioxide the atmosphere will no longer support combustion. Experiments show that the percentage of carbon dioxide added to the air required to extinguish fire varies materially with different burning substances, varying from less than twenty per cent to over fifty per cent. Temperature and draft conditions also affect the concentration of CO_2 necessary to extinguish fire, as at high temperatures and where there is a draft a much smaller amount of oxygen is necessary to maintain combustion. In practice a concentration of from 25 to 30 per cent of carbon dioxide is considered sufficient to extinguish the flame of gasoline vapor and ordinary combustible materials.

Cooling Effect.

The rapid expansion of the liquefied gas produces a refrigerating effect—which is utilized commercially in carbon dioxide refrigerating systems. A portion of the carbon dioxide solidifies into snow, which has a temperature of minus 110° F. The cloud of snow gives the discharge a characteristic appearance somewhat resembling steam. The snow soon sublimes into gas, absorbing heat from the burning material or surrounding atmosphere. The CO_2 snow has a latent heat of 235 B.T.U. per pound, but only part of the liquid in the cylinder forms snow, so that the total cooling effect of the gas and snow is about 100 B.T.U. per pound. This is small compared with water, which has a theoretical cooling effect of about 1000 B.T.U. per pound, assuming that the water is all evaporated into steam. It has a relatively more effective cooling action than would be thus indicated, however, because owing to the manner in which the CO_2 snow is formed its cooling effect is almost instanta-

Test of a carbon dioxide room-flooding system on an oil and gasoline fire. Flowing gasoline was continually sprayed into the building. This fire was extinguished in less than half a minute.

neously available, whereas under ordinary fire conditions only a part of the cooling effect of water is actually utilized.

The refrigerating effect of the rapid expansion of carbon dioxide, while a valuable factor in its application to fire extinguishing, was the principal difficulty to be overcome in the development of this form of protection, for unless specially designed equipment is used the cooling effect and formation of CO_2 snow takes place inside the cylinder or piping instead of outside, and freezes and clogs the discharge passage, so retarding the discharge of the gas as to render the device ineffective.

In the modern CO_2 equipment this difficulty has been entirely overcome. The means employed include the use of a siphon tube to take liquid CO_2 from the bottom of the cylinder instead of gas from the top, large discharge passages to minimize the pressure drop inside the apparatus and especially designed discharge orifices.

Action on Burning Gases, Liquids and Solids.

Both the smothering and cooling effect of carbon dioxide are factors in its fire extinguishing action. It is particularly effective on burning gases, and on flammable liquids which vaporize to burn as gases. In considering the action

of CO_2 on flammable liquid fires it should be noted that the combustion is a surface phenomenon, only a thin layer of the liquid being heated to the burning point, the bulk of the liquid being relatively cool, particularly in the early stages of a fire. In the case of gases and flammable liquids extinguishment can be effected almost instantaneously, and unless the fire has been burning for a considerable period surrounding objects are not heated sufficiently to cause reignition. It is for this type of fire, where it is unnecessary to maintain a fire extinguishing atmosphere for more than a few seconds, that this type of protection is best suited. It is most effective when the CO_2 is released at a very early stage in the fire by means of sensitive heat-actuated automatic devices.

Fires in solids involve a somewhat different problem. The flame from the burning material can be extinguished instantaneously by means of carbon dioxide, but the incandescent material remaining will reignite as soon as air again reaches it, unless the inert atmosphere is maintained until the material cools below the burning point. In some special cases it is practicable to maintain a fire extinguishing atmosphere in a closed space for the period necessary for such cooling. Some such applications of CO_2 have already been developed and further development work is being done along these lines, but in the present state of the art carbon dioxide is not considered generally practical as an extinguishing medium for fires in ordinary combustible materials.

Carbon dioxide has the important advantage of permeating cracks and similar spaces that could not be reached by water.

A Stored Pressure Device.

The effectiveness of carbon dioxide extinguishment is entirely dependent upon maintenance of the initial gas charge in the cylinders. In view of the fact that the pressures range from 750 to 1,000 lbs. per sq. in., special precautions must be taken to prevent leakage. No ordinary valve which would permit the quick opening of a relatively large passage (as necessary for the proper functioning of the device) would be sufficiently tight to withstand the high pressure of the gas without leakage. Two methods have been developed to meet this problem—one a thin metal disc which is cut or punctured to release the gas, and the other a specially designed valve.

Leakage tests at the factory before shipping cylinders should eliminate practically all leaky cylinders. In subsequent inspection there is no visual evidence of loss of gas, but this can be readily detected by semi-annual weighing. A plan followed in some fixed installations is to mount the cylinders permanently on platform scales, with an alarm to give warning in case the weight falls below a predetermined figure.

Another method to give warning of leakage, applicable to certain forms of carbon dioxide devices, is to place a thin gas tight membrane over the outlet which will be ruptured by the gas in case of leakage and thus give visual evidence of the loss of gas.

Advantages, Limitations, Suitability.

The foregoing discussion leads to a summary of the points of advantage and limitation of carbon dioxide fire protection. Some of these points have been already mentioned; others require no detailed discussion.

The points of advantage may be listed as follows:

1. No damage, no residue, nothing to be cleared up after a fire.
2. Penetrates confined spaces.
3. Quick action.
4. Non-poisonous.
5. Non-conductor of electricity—may be used on live electrical apparatus.
6. Does not freeze—may be used in unheated spaces.
7. Good until used—no recharging required except after a fire.

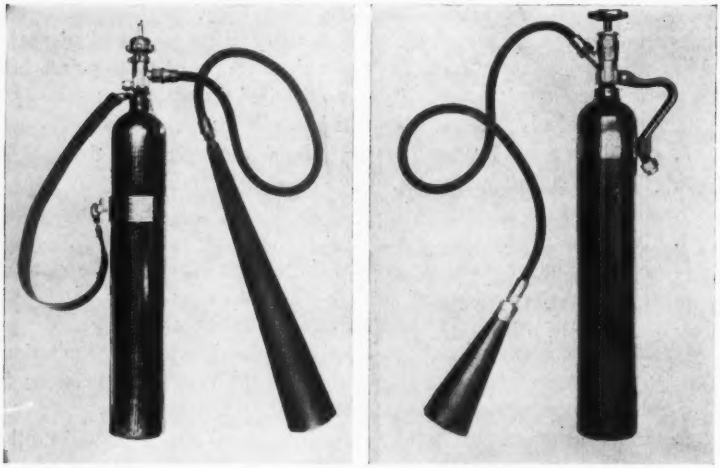
Offsetting the above advantages are certain disadvantages or limitations, which, however, have been largely overcome in the various applications for which carbon dioxide protection is recommended. These are:

1. Can be applied successfully only in confined spaces or under other conditions where the fire can be completely enveloped by the gas.
2. Does not quench large masses of incandescent solid material.
3. Hand extinguishers have limited range and relatively short discharge period; trained personnel necessary for efficient use.
4. Supply of gas cannot ordinarily be replenished during a fire—discharged cylinders must be replaced by full cylinders, recharged from other cylinders, or sent to CO_2 plant for recharging.

Carbon dioxide is peculiarly suited for the extinguishment of certain special types of fire that cannot be readily controlled by other fire extinguishing devices. Among these are fires in flowing gasoline and fires in open tanks of alcohol. Foam protection is not suitable for either of these types of fires. Where gasoline is flowing as from a leak in a tank, the flowing gasoline constantly presents a fresh surface not covered by foam. Likewise foam protection is not suitable for alcohol fires because the alcohol dissolves the foam.* It is not to be inferred, however, that carbon dioxide is the only possible means of extinguishing such fires, for alcohol fires can be extinguished by the use of a large amount of water to dilute the liquid, and fires in flowing gasoline might be extinguished by means of a steam smothering equipment or other inert gas.

Carbon dioxide is generally suitable for fires in gasoline and other common gases and flammable liquids, subject to the practical limitations of its application. Carbon bisulphide fires may be extinguished by means of CO_2, but the percentage of the gas required is much higher than with other flammable liquids, and sub-surface application of water is considered a more suitable form of protection where conditions permit its use.

*This statement applies primarily to ethyl and methyl alcohol; the same solvent action exists with the heavier alcohols such as butyl alcohol, but because of the greater viscosity is not so serious.



Factory Mutual Record.

Typical portable carbon dioxide extinguishers of the seven-pound size.

Pyroxylin lacquer fires, just as fires in other flammable liquids, may be extinguished by CO_2, but it may not be effective on fires in pyroxylin lacquer residues, as the material itself contains sufficient oxygen so that when once decomposition is well under way, cutting off the supply of oxygen in the air does not extinguish, and to check this decomposition a greater cooling effect is necessary than it is practicable to obtain with CO_2.

Carbon dioxide is well adapted for use in certain types of electrical equipment fires, as will be discussed later.

Portable Extinguishers.

Portable CO_2 extinguishers are made in several sizes, the principal size of hand extinguisher containing about 7 lbs. of CO_2. A 15 lb. size hand extinguisher is a newer development. Larger units consist of one or more 50 lb. cylinders mounted on a wheeled truck. These extinguishers consist essentially of the cylinder of CO_2 and a short length of hose terminating in a cone shaped discharge nozzle or horn designed to reduce the reaction effect and to prevent the high velocity jet carrying entrained air with it to the seat of the fire. The cylinders are provided with a disc closure or a special valve, as described previously, the disc being punctured or the valve opened by operation of the control handle.

This type of extinguisher was first developed for use on fires in telephone switchboards and is already in general use for this purpose, for which it is particularly suited. If water or any electrically conducting extinguishing liquid is used on this type of fire all circuits wet become short circuited and a damage results which may be enormous in proportion to the actual amount of the fire. In this type of fire the only combustible material is the insulation

on the wires; this presents a relatively small mass of burning solid material and when attacked in an incipient stage such a fire can be readily controlled by the carbon dioxide extinguisher.

This type of extinguisher is also effective for various other special uses, including fires in small open tanks of flammable liquid, gasoline spilled on the floor, etc. Tests indicate that with proper manipulation the 7 lb. size will extinguish a fire in an open tank with 5 square feet of gasoline surface, or 10 square feet of alcohol surface. Under especially favorable conditions fires in larger areas may be handled, but with larger areas there is danger of reignition.

Telephone Topics.

Testing a carbon dioxide extinguisher on a fire in a telephone relay rack bay.

While the discharge cone can be designed to project the stream of carbon dioxide snow and gas distances comparable to the range of other types of hand extinguishers, a long range stream is ineffective on fires of any considerable size, and the small extinguishers now in use require approaching the fire to within six feet for effective use. Any fire of size within the limits of extinguishing capacity of the device can ordinarily be approached closely; the discharge from the extinguisher tends to screen the operator from the heat of the fire to some extent.

The steel cylinder strong enough to withstand the gas pressure necessitates a total weight of the device which is large in relation to the weight of the gas; the total weight of the 7 lb. portable extinguisher is in the neighborhood of 35 lbs. While the weight of carbon dioxide extinguishers is considerable, it is not excessive compared with foam extinguishers of similar extinguishing capacity.

Both Underwriters' Laboratories and the Factory Mutual Laboratories have tested and labeled the 7 lb. hand CO_2 extinguisher.

Permanent Piped Installations.

Extensive hazards, beyond the capacity of the portable extinguishers, require permanent piped CO_2 installations. These have the advantage that they may be arranged for automatic operation; the CO_2 may be released by the use of any of the electrical or mechanical heat actuated devices already in common use for fire protection purposes. The detail of the heat actuated and

release devices employed with CO_2 systems involves no new principle of fire protection, and as these devices are already well known, they need not be described here.

One feature of special interest is the utilization of the gas pressure to close windows, operate dampers, valves, etc., through pistons or other pressure operated devices connected to the CO_2 piping system. In large systems employing a considerable number of cylinders the same principle is utilized to open additional cylinders where the force of the initial operating mechanism may not be sufficient to open more than a few cylinders.

In permanent piped systems the cylinders may be located at any convenient place, the piping system bringing the CO_2 to the hazard to be protected. The piping system and all valves and fittings used must be designed to withstand the high pressure, with pipe sizes and outlets so arranged as to distribute the gas properly and to ensure that the main expansion and cooling effect will take place at the point of application rather than in the system. Present practice indicates that relatively small pipe sizes may be used.

Where several hazards are protected in one plant, a single battery of cylinders may be used with an appropriate valve mechanism to direct the gas to any given point in case of fire.

For most applications the system is arranged for simultaneous discharge of all the cylinders, with no reserve provided, but where conditions require a continuous supply of the gas over a considerable period of time, as in the case of electrical generators, the cylinders may be arranged to release progressively in order to maintain any predetermined concentration of CO_2.

As at present developed permanent piped carbon dioxide extinguishing systems seem particularly applicable to the following types of hazards:

Dip tanks.

Enamel and other baking ovens.

Textile and other dryers.

Electrical generators, switchboards, etc.

Dry cleaning machinery.

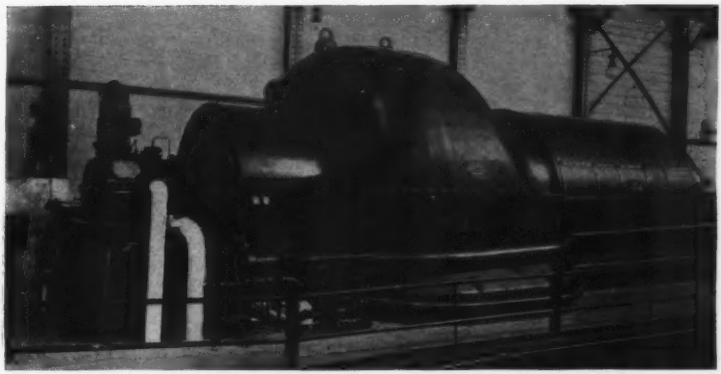
Paint and varnish mixing, oil boiling, and similar flammable liquid hazards.

Fur vaults.

Record vaults.

Electric Power House Installations.

Fires in high potential electrical equipment can be attacked with water, soda acid, foam or other conducting extinguishing agent only after the equipment is made electrically dead. Furthermore, electrical equipment wet during fire fighting operations can be put back into service only after a period of drying which may require several days. Carbon tetrachloride, a non-con-



Factory Mutual Record.

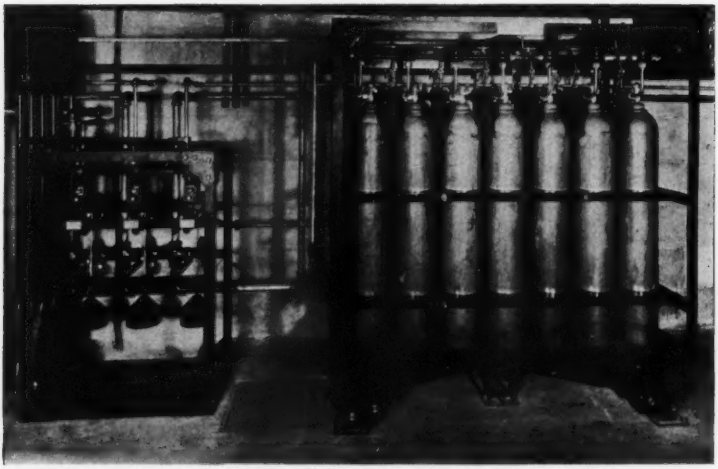
A turbo-generator protected by a carbon dioxide system. The gas is piped into the cooling system which opens into the machine through the floor from below.

ductor of electricity, may be used on live electrical equipment, but is said to have an injurious effect on some types of insulation in common use.

Carbon dioxide has none of these disadvantages for electrical power house use, and has the advantage of extinguishing fire with a minimum of interruption to the operation of the station, which is of great importance because in most situations the maintenance of a continuous supply of electrical power to the distribution system is a far more important consideration than any question of property damage to the station itself.

The principal installations in electric power houses are for the purpose of protecting turbo-generators and other rotating electrical equipment. Turbo-generators of modern design are customarily arranged for the circulation of cooling air through the machine. Where a closed system is employed carbon dioxide can be used very advantageously. Otherwise, it is necessary to install dampers to cut off the air supply; these can be operated automatically with the CO_2 system.

The system may be arranged for either manual or automatic operation, the latter by differential relays which are designed to turn on the gas when an internal short circuit occurs. In a large power plant, where there are a number of turbo-generators, a single battery of cylinders may be arranged to protect all of the generators through the use of automatic valves to turn the gas into the proper machine in case of fire. The gas can be introduced immediately, without waiting to deënergize the machine. The current is then cut off and the carbon dioxide is maintained during the period of half an hour or so before the machine, rotating by momentum, finally comes to a stop; or in case the rotor is stopped by electrical braking or other means, until the coils have cooled sufficiently to prevent any reignition of the insulation.



A battery of carbon dioxide cylinders piped to protect large turbo-generators in a power house. Gas is automatically released from the cylinders in case of fire and directed into the proper machine by the special valve equipment shown at the left.

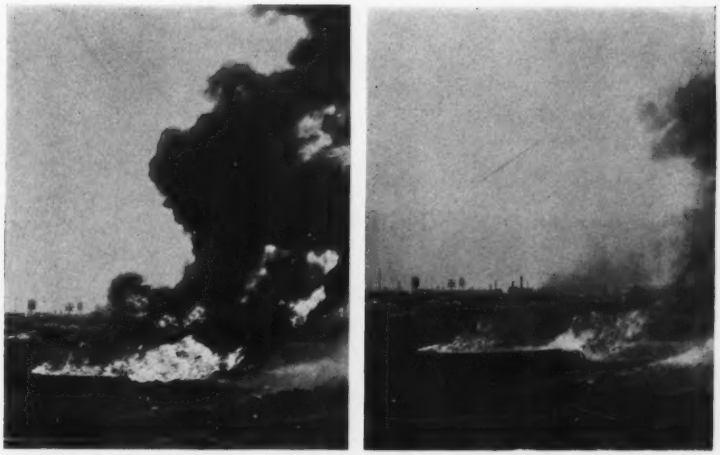
The amount of gas required, as in other applications of this form of protection, varies in accordance with the particular type of equipment used. The amount of gas supply is designed to furnish a concentration of 25 to 30% of carbon dioxide for the period while the machine is still rotating, followed by a lesser concentration (usually about 20%) for a subsequent period. Under average conditions a supply sufficient to give a concentration of 25% for forty-five minutes is considered adequate. One of the factors entering into the amount of gas storage required is the tightness of the casing. This can be determined by leakage tests.

Transformer vaults and oil switch rooms may also be protected by carbon dioxide. In such locations, where burning oil may escape from the apparatus, the installation may be of the room-flooding type, as described on a following page.

Dip Tanks, Etc.

A number of installations of carbon dioxide have been made in dip tanks, for which this type of protection has the advantage of involving no damage to the enamel or other liquid used, and causing a minimum of interruption to production. The advantages of CO_2 protection are particularly apparent in the case of large dip tanks, where continuous dipping is done on a production basis using overhead conveyors, and where extinguishment by automatic covers is not practicable.

Two means have been employed for extinguishing dip tank fires with CO_2; one, the application of the gas through orifices arranged around the top



Test fire in an open oil tank of 400 square feet area. View at the left shows the character of the fire. View at the right was taken during the application of carbon dioxide through a sub-service piping system just prior to the complete extinguishment of the fire.

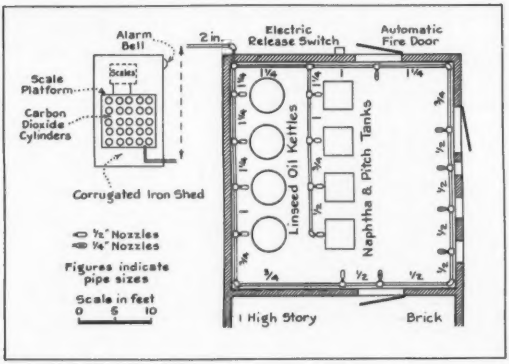
of the tank, thus forming an atmosphere with a high percentage of CO_2 close to the liquid surface; the other, introducing the gas through perforated pipes in the bottom of the tank so that the gas will bubble up through the liquid and thus reach the base of the flame at the liquid surface. Both methods appear to be effective. For most installations the sub-surface application seems preferable, as it avoids the difficulty of possible clogging of orifices around the top of the tank. Mechanical features of tank design and operation make the surface application preferable in some instances.

In addition to the dip tank proper, CO_2 protection can be arranged for drain boards, ovens, and other adjacent points of special hazard. Oil tank fires or fires in open tanks of any ordinary flammable liquid may be extinguished in a similar manner, but this form of fire extinguishment has not as yet been used for the protection of large oil storage tanks.

At the present writing no general statement can be made as to the amount of CO_2 required to protect any given flammable liquid area, but present practice indicates the proportion of one pound of CO_2 per square foot of liquid surface under average conditions, the exact amount required varying materially with the character of the liquid, the temperature, design of the tank, and various other factors.

Room Flooding Systems.

Carbon dioxide flooding systems for rooms enclosing processes where flammable liquids are used constitute merely an extension of the applications previously described. They are particularly applicable to rooms containing a



Factory Mutual Record.

A typical layout of a room-flooding system for an extra hazardous area.

number of units of hazardous equipment, where it may be more advantageous to flood the entire area than to attempt to provide individual protection for each unit. Such systems may be designed, where required, to maintain an atmosphere of carbon dioxide for a considerable period of time in order to allow heated materials to cool below the reignition temperatures.

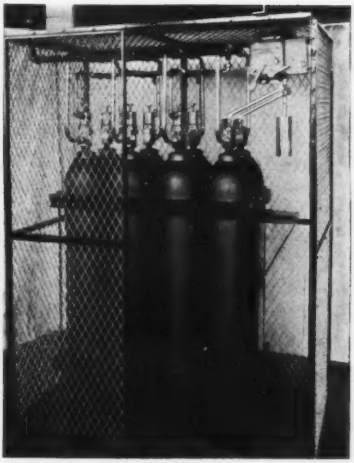
Successful application does not require an air-tight room, for the carbon dioxide supplied is sufficient to overcome any ordinary leakage. Doors and windows can be closed automatically with the operation of the system, and openings that because of the nature of the occupancy must be left open, can be cut off by means of a screen of carbon dioxide discharged from orifices appropriately located around the edges of the opening. Strong drafts tend to interfere with the operation of the system; this factor should receive careful consideration in planning CO_2 installations.

The amount of carbon dioxide required to flood any room protected must be sufficient to dilute the atmosphere of the room to the desired degree, with an additional amount to compensate for leakage or to screen any permanently open doors or windows. If the nature of the hazard is such as to require maintenance of the fire extinguishing atmosphere for any length of time, the supply of CO_2 must be still further increased. In rooms of average size, where doors and windows can be closed, the present thought is that one pound of CO_2 should be ample for from 10 to 20 cubic feet of room space, a relatively greater proportion of gas being required for a small space and lesser for a large space. This is explained by the fact that the ratio of wall area (and consequent opportunity for leakage) to volume is greater in the smaller space.

Room flooding systems may be designed for either manual or automatic operation. Where the spaces protected are large, an alarm bell and time delay

Factory Mutual Record.

Exterior view of a dry cleaning room protected by a piped system of carbon dioxide. The shutters are designed to close automatically and prevent leakage of gas in case windows should be broken by an explosion.



A battery of cylinders for a fixed carbon dioxide installation, showing release mechanism and piping. The first two cylinders are opened directly, the gas pressure then actuating pistons which open the other cylinders.

device may be used to give ample opportunity for evacuating the room before the doors are closed and the gas introduced.

Fur Storage Vaults.—Record Vaults.

Fur storage vaults, with very valuable contents particularly susceptible to water damage, may be effectively protected by CO_2 flooding systems, according to the available test data. Here the construction is normally sufficiently tight as to minimize the infiltration of air through walls, there are few window or door openings, and the carbon dioxide may be maintained in the vault for a sufficient period to allow for cooling.

Record vaults are another similar application of carbon dioxide extinguishing where contents are extremely valuable, where water damage would be very heavy, and where a tight closure can be maintained for a long period. Few such installations have as yet been made, but record vaults would appear to be a promising field for the further development of this form of protection.

Concealed Spaces.—Bulk Storage.

It has been suggested that fires in concealed spaces such as hollow partitions might be effectively fought by means of carbon dioxide, and municipal fire departments might carry CO_2 equipment for such use. While such use is theoretically practicable, there might be difficulty in maintaining the gas in the closed space until the glowing embers had cooled sufficiently to prevent

reignition, and also difficulty in determining when extinguishment was completed. At any rate, no development work has been as yet done along these lines which would permit drawing any conclusions as to the eventual practicability of such fire department use of carbon dioxide. Several fire departments now carry portable CO_2 extinguishers as a part of their equipment, but this is intended only for the various special hazard uses already described. In this connection the following quotation from a letter written by Chief August Emrich of the Baltimore Fire Department is of interest:

> The Rescue Squad of the Fire Department of Baltimore has in its equipment two Carbon Dioxide Fire Extinguishers, which have been used for the extinguishment of electrical and acid fires upon several occasions. The department also has installed in Headquarters two Carbon Dioxide Fire Extinguishers for emergency use in the event of electrical fires.
>
> The extinguishers as stated have been in service a number of times with most excellent results.

Likewise, carbon dioxide may prove a suitable means of fire protection for bulk storage of various materials, but this has not as yet been investigated.

Availability of Equipment.

Carbon dioxide equipment is manufactured by several established concerns specializing in this form of fire protection. Several types of CO_2 devices have already been tested and listed by Underwriters' Laboratories and the Factory Mutual Laboratories. While much of the equipment used is patented, it is said that there are no basic patents covering the general principles of carbon dioxide fire protection, and the development of this new method of fire extinguishing appears to be proceeding on a sound basis.

N.F.P.A. Regulations.

The N.F.P.A. Committee on Manufacturing Risks and Special Hazards has in course of preparation a set of regulations on carbon dioxide extinguishing systems which will parallel in a general way the present regulations on foam extinguishing systems developed by the same committee. An outline of the proposed regulations on carbon dioxide will be found in the 1928 Proceedings, page 395. The committee will welcome any suggestions on this subject; communications addressed to the Executive Office of the N.F.P.A. will be transmitted to the committee.

ACKNOWLEDGMENT. Valuable assistance in the preparation of this article has been rendered by several N.F.P.A. members, including: Mr. Wm. D. Milne, chairman N.F.P.A. Committee on Manufacturing Risks and Special Hazards, and Mr. Benjamin Richards, chairman sub-committee on carbon dioxide systems; Mr. E. J. Smith and Mr. A. H. Nuckolls of Underwriters' Laboratories; Mr. A. L. Brown of Factory Mutual Laboratories. Illustrations and certain details of the text have been made available through the courtesy of the *Factory Mutual Record*. Walter Kidde and Co. have assisted with criticisms of the text and have supplied illustrations. Mr. Alexander McKinny of the Fyre-Freez Corporation has made helpful suggestions. Mr. C. L. Jones has contributed photographs and advised respecting the text on behalf of the American-La France & Foamite Industries.

Aviation Fire Hazards.

Fire is an important factor among the hazards of aviation. A considerable proportion of the accidents involved are caused by fire, fire being either the originating cause or following a crash. A record of fires in airplanes and hangars which have been reported to the N.F.P.A. Department of Fire Record appears on a following page. While the total number of casualties summarized in this record is perhaps not large, it should be remembered that the N.F.P.A. has no facilities for securing complete records, and that the actual number of fires which have occurred within the past few years is probably much greater than that recorded.

Public interest seems to be focused on the fire hazards of aviation and a number of agencies are already giving this matter attention. The tests of airplane crashes carried on by the Matériel Division of the U. S. Army Air Corps and described in the July 1928 QUARTERLY, page 70, indicate one way in which the problem is being attacked. These tests showed that the principal hazards of planes are the hot exhaust stacks and the wiring system. The tests also showed the disintegration of the plane structure which occurs in a crash and which results in the scattering of gasoline, which is all too frequently ignited from the hot exhaust stacks or electrical system of the plane.

The problem of airplane fires appears to be of international importance, thus differing from the problems involved in building fires which have already been solved to a considerable extent in European countries by the use of a higher proportion of non-combustible building materials. An illuminating sidelight on the French viewpoint of this subject is contained in an article in the *Journal des Débats* (Paris) by Lieut. Colonel Paul Renard, published in the issue of August 25, 1928. The following is a translation from that article, appearing under the title "Assez de pilotes brûlés vifs" (Enough pilots burned alive).

"It is a little more than a year ago, in reporting an inquiry into the aeronautical situation, that I drew the reader's especial attention to the opinion of M. André Michelin, and I am indebted to him for the title of my present article. He stated that during the three years, 1924, 1925 and 1926, there have been 131 victims of fires in French aviation; of these seventy-one were killed and forty injured. This is a frightful number in proportion to the relatively small number of flights.

"I have many times had occasion to comment that one of the causes of the reluctance of our countrymen to take advantage of the available aviation facilities is their lack of confidence in the safety of air transportation, and particularly the fear of fire.

Herbert News Photo.

The wreckage of a London-Paris air liner which fell in flames near Penshurst, England, while on the way from Paris to London. Seven persons were burned to death.

"This is not a new theory; a similar situation existed when railroads were first introduced. They had been in use only a few years when, on May 8, 1842, a catastrophe occurred on the Versailles line. A hot box blazed up and fire communicated to the train. In those days it was feared that the passengers might get the idea of jumping out of the train while in motion, and to avoid this danger it was customary to lock the compartment doors from the outside. The train stopped when the fire was discovered; the passengers naturally tried to get out but could not do so by reason of the locked doors and a great number of them were burned alive. This accident made a profound impression which persisted for a long time. I remember having heard twenty years later—I was then eight years old—in reply to a man who announced his intention of going to Paris by railroad, 'What, do you dare ride on a train after the accident of the Rive Gauche?' I knew a number of people who died about 1870 without ever having ventured upon a railroad train.

"Thus for thirty odd years the influence of this catastrophe materially retarded the development of railroad travel. Today, no one remembers it. Only a very few people know that the accident took place between the stations of Mendon and Bellevue, that there is on the site a memorial in the form of a triangular chapel called Notre-Dame des Flammes. It is situated in the courtyard of a school which is not open to the public, and its existence is generally ignored. However this may be, we must expect that the fear of fire will have a material influence upon the extent of air travel.

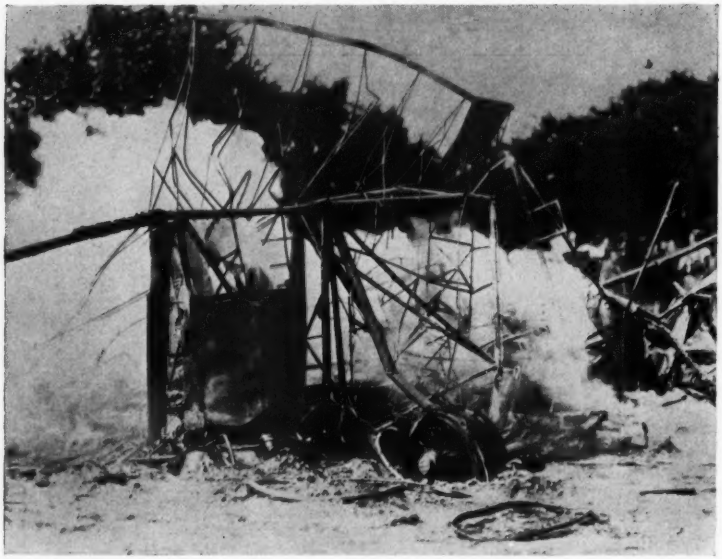
"Unfortunately, in 1927 and 1928 the situation does not seem to be appreciably bettered, and without giving any statistics of recent fires it is sufficient to cite the death of the pilot Fronval in a fire on June 27, 1928, and the similar accident at Vincennes on June 30 during the air meet. It is high time that this be stopped, and on this point everybody is agreed. But how to accomplish it?

"It should be noted that fires in the air are infrequent; most airplane fires occur after crashes. Gasoline escapes from tanks or broken piping and always seems to reach some source of ignition. The hot exhaust pipe is a point of particular hazard. The result is that accidents which would otherwise be minor, with only slight damage to the plane, become catastrophes. Naturally, attention has been given to the prevention of such fires and various safety measures have been suggested. Parachutes have been used successfully in escaping from burning planes; unfortunately, parachutes do not always give safety, for experience shows that it is sometimes difficult to make use of them when a plane is burning. Moreover, they are effective only in flight, and we have seen that such fires are infrequent.

"Fire extinguishers have been proposed; these have been successful in some instances in saving life. Devices have been developed to prevent backfire. Attempts have been made to cool the exhaust gases. It is obvious that none of these measures may be neglected, but they are at best but palliatives. The real remedy, the only effective one, will be a fuel much less volatile and less flammable than the gasoline now used. This involves great difficulty, for up to the present time the use of light weight motors has only been possible with aviation gasoline. If a less flammable fuel is used the weight of the motor must be very greatly increased. This is the present status of the situation, but there is no reason to believe that it cannot eventually be improved. There is no theoretical obstacle to the development of light motors employing a less dangerous fuel.

"We must thus direct our researches along these lines, and if some generous patron would donate two or three millions to found a laboratory to be devoted to the development of a less volatile fuel for airplane motors, he would make the greatest possible contribution to aviation."

The conclusions of the author of the above article are very interesting, and while there may be some difference of opinion as to the means to be employed, the general reasoning of the author and the intent of his conclusions clearly have an international application. Since its publication, announcement has been made of the development by an American automobile builder of a Diesel type airplane engine designed to use a relatively heavy fuel. No prediction can at present be made as to the future of this new type of engine, but its development will be watched with much interest from the fire hazard viewpoint.



Wide World Photo.

One man was killed and another seriously injured when this plane crashed and was destroyed by fire at Reynoldsburg, Ohio. Three other occupants escaped by parachute.

Life Safety Measures.

Safety to life from airplane fires calls first for all possible precautions against the start of fire, and second, prompt escape of the occupants in case fire does occur despite precautions. Fire extinguishing appliances, because of the weight involved, cannot be provided with sufficient extinguishing capacity to be relied on as a life safety measure. In the case of fires in the air, immediate descent with the hope of landing before the whole plane is involved, or a parachute jump, seem to be the only alternatives. In the case of fire following a crash, or while the plane is on the ground, passengers must escape from the plane immediately. With closed cabin planes this cannot always be done readily.

Major R. H. Mayo, Bristol representative of the Daniel Guggenheim Fund for the Promotion of Aeronautics, in a paper presented before the National Safety Council, October, 1928, commented on this subject as follows: "Apart from the question of power plant installation the most important precaution for the safety of passengers is the provision of ample facilities for passengers to get out of the cabin after the crash. Except in the case of a very bad crash the airplane rarely bursts into flames immediately; there may be, in

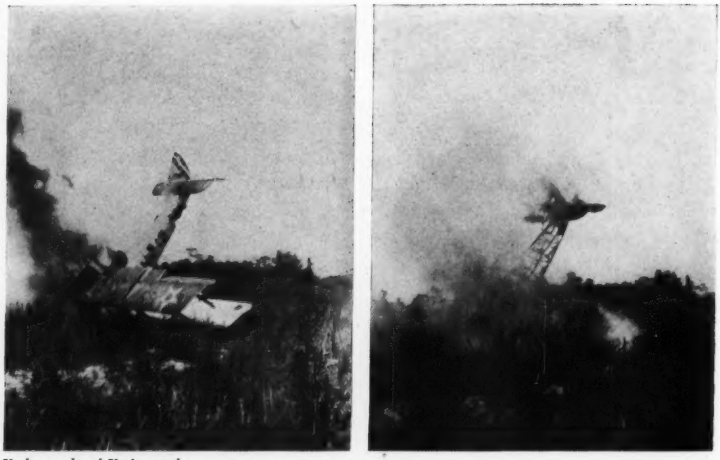
Herbert News Photo.

This plane caught fire in the air and crashed near Willowville, Cal. The fall was broken by high tension wires and the two aviators miraculously escaped with their lives.

fact, an appreciable interval before the fire breaks out and a considerable time before any fire reaches the cabin. Reliance should not be placed on the main door alone, as this may be blocked or jammed. Two or three emergency exits should be provided in the roof, and every window should be large enough to permit of the exit of passengers in emergency."

Parachutes constitute a means of escape from a fire in a plane in the air, and have been used successfully in a number of instances. Parachutes are regularly carried on planes in U. S. government service, but are very little used on commercial planes. There seems to be some question as to the practicability of the use of parachutes as a safety measure in ordinary commercial flying, according to Major Mayo, who says on this subject:

There is one important factor which is common to all classes of accident, namely, that unless there is a complete disaster, such as structural failure or head-on collision in the air, neither the pilot nor the passengers know until the last moment whether a crash is inevitable. In the event of disaster parachutes could very rarely be used successfully by passengers, and their use while the issue is still in doubt is undesirable. The pilot's attention should be concentrated on avoiding accident, and it may be dangerous to saddle him with the responsibility of instructing passengers to leave the airplane. It would obviously be undesirable for passengers to decide for themselves. The carrying of parachutes would involve a considerable sacrifice of paying load which cannot be afforded, and, even if provided, they would seldom if ever be of any value.



Underwood and Underwood.

Airplane destroyed in U. S. Scout Fleet practice at Norfolk, Va. Picture on the left shows the start of the fire; the picture on the right shows the plane practically destroyed in three minutes.

Means of Preventing Fire.

The several measures that may be employed for the prevention of airplane fires, and the experimental work that has been done along these lines by the U. S. Army Air Corps at Wright Field, Dayton, Ohio, were described in the July 1928 QUARTERLY (Vol. 22, No. 1, p. 70). This work has resulted in the following recommendations by the Matériel Division of the Air Corps:

(1) *Structural.*

(a) Ventilate all compartments to prevent any accumulation of gasoline or oil vapors and to preclude any chance of their being ignited.

(b) The fire wall should fit closely to the cowling all around the section of the fuselage, and when longerons, pipes, wires, and control members pass through it the clearances should not be larger than necessary for assembly, and after assembly all openings should be closed with a flexible material which would delay the progress of flames. Holes through which non-movable members pass should be closed by rubber grommets, rawhide or sheet asbestos and, for holes through which movable members pass, rawhide is suggested. The fire wall should have an edge of approximately one-fourth inch turned forward to act as a deflector for oil or gasoline and as a drain through the bottom of the engine compartment instead of permitting oil or gasoline to seep through the seams into the fuselage. Fire walls should not be painted or varnished except when a battery is mounted close to it, then acid-proof paint may be applied to prevent corrosion in the vicinity of the battery only.

(c) The engine compartment should be kept free from oil and dirt.

(2) *Electrical.*

(a) Where bare or lightly insulated high tension parts are used they should clear the parts of the engine and airplane, which are normally at ground potential, by at least three-fourths of an inch.

(b) All connections of high tension wire requiring safety wire or other fastenings should be insulated to withstand the same potential as the wire covering.
(c) All bare high tension conductors and all bare safety devices should be covered by protectors of an improved type.
(d) Eliminate metal identification tags on ignition wires.
(e) Keep the whole ignition system clean,—the less oil and dirt present the less the hazard.

(3) *Fuel and Oil.*
(a) Air-pressure gasoline feed should not be used.
(b) All lines will be so installed as to prevent oil or gasoline leaking or being sprayed on to high tension conductors or exhaust stack in case of leaky or broken joints.
(c) All drain pipes and vent lines should be long enough to extend 2 inches outside the cowling or fuselage and so located that drainage cannot be returned into the aircraft. They should be so supported that they cannot be bent out of place when removing or replacing cowling.
(d) Where there is a possibility of relative movement between any support or connections there should be a flexible joint placed near each point of support or connection.
(e) The carburetor air scoop should not have recesses or plugged openings which will allow gasoline to stand in puddles.
(f) Gasoline tanks should be located where they will not spill their contents over the engine. Suggested locations for gasoline tanks for single-engined airplanes are listed in order of preference:
1st—Droppable tanks.
2nd—Lower wing, near side of fuselage.
3rd—Bottom of fuselage, rear of fire wall.
4th—Section of fuselage, behind fire wall.
5th—Upper wing, outside of center section.
(g) Locate gasoline tanks so as to be subject to as little shock as possible in case of a crash.
(h) Provide for dropping the gasoline tank instantaneously in flight by a mechanism operated by the pilot; this mechanism to be so located that it can be readily inspected without the removal of the cowling.

(4) *Exhaust.*
(a) The cowl openings through which the exhaust system passes should have a minimum of clearance to allow for passage of stack.
(b) The outer ends of exhaust stacks should be cut at 90 degrees.
(c) The manifold type of stack should be at least 4 inches from the cowl or fuselage on the inside, parallel to the fuselage. The individual type of stack should protrude at least 6 inches outside the cowling.
(d) The exhaust system should pass the following ground fire test:
1st—Run engine to normal running temperature.
2nd—Induce all possible extra heating by leaning the mixture and retarding the spark. After getting the exhaust system as hot as possible, shut off the gasoline supply to the carburetors and, as soon as the motor stops, inject 1 ounce of mineral lubricating oil in stacks Nos. 4, 5 and 6 from the front.
3rd—Repeat this same procedure with aviation gasoline.
4th—Each operation to be repeated three times with no flame resulting.
(e) Individual aluminum air-cooled stacks are recommended for all engine installations or no stacks at all, except for special missions.

(5) *Extinguishers.*

(a) Installation of a combination hand and fixed fire extinguisher on all aircraft is recommended.

Lightning.

Lightning is an obvious hazard to airplanes, either by starting fire in the plane or killing or disabling the pilot. The violent air currents which accompany thunder storms likewise involve serious hazard. Where planes have come to grief during thunder storms it is difficult to say what part lightning or resulting fire may have had in the disaster. Little is known as to the exact nature and extent of the hazard to airplanes; but prudent pilots avoid thunder storm areas.

Airplanes and Hangars—Fire Record.

Thirty-five fires in planes and ten fires in hangars have been reported to the N.F.P.A. Department of Fire Record within the past few years. This relatively small number represents probably only a fraction of the total number of such fires which have occurred. The usual reporting channels do not cover airplane fires and a great deal of the data has accordingly been extracted from newspaper reports. While these original reports are in many cases incomplete or of questionable accuracy in technical detail, the main features covered may be assumed to be accurately described, and owing to the nature of the fire, which frequently destroys the plane completely and burns the occupants to death, considerable difficulty would be anticipated in obtaining authentic detailed information as to causes of fires, even if investigated and reported on by inspectors especially trained in this work. It would be very desirable in the further study of the problems involved if some more accurate and complete fire reporting system could be devised. N.F.P.A. members and other readers of this article are requested to coöperate in the compilation of additional data and are requested to send to the Executive Office as complete data as can be obtained about any crash or fire that comes to their attention.

Airplane Fires.

The following is a summary of the data regarding the circumstances of the fires in planes.

Circumstances of Fires.

	Fires with Loss of Life	Fires with No Loss of Life	Number of Lives Lost
Ignition in Air	10	3	19
Fire Following Crash in Takeoff	3	0	7
Fire Following Crash in Forced Landing	15	2	28
Fire in Plane at Rest	0	2	0
Totals	28	7	54

Henry Miller News Picture Service.

A crash and fire near Berlin, Germany. Men in foreground are attacking fire with hand extinguishers.

Cause of Forced Landings.

	Fires with Loss of Life	Fires with No Loss of Life
"Engine Trouble"	4	2
Storm	1	0
No data	10	0
Totals	15	2

FIRES IN THE AIR. In two of the three fires which started while the plane was in the air, but where there was no casualty, the pilots used parachutes successfully. In the other the plane was flying at a low altitude and was safely landed. In one of the fires where a man was killed the pilot used his parachute successfully but his mechanician did not. This indicates the desirability of parachutes as a means of saving life. About half of the fires took place while planes were near the ground and the other half took place when the planes were well up—2000 feet or more. This shows that in at least half the cases there would be ample opportunity to use a parachute if one is provided.

Data as to how the planes ignited in the air were not at all definite. In two cases they were attributed to leaking gasoline. In a third case a wing broke, but how this caused a fire is not stated.

FIRES ON THE GROUND FOLLOWING CRASHES. As shown by the preceding table there is little data as to how the fires started. Most of the reports described a very rapidly spreading and intense fire, so that it may be presumed

Herbert News Photo.

Photograph taken immediately after the crash of a plane which caught fire in the air at Del Mar, California. The three occupants were burned, but not fatally.

that it was largely gasoline that was burning, having been scattered over the wreckage by the rupture of the fuel tanks.

FIRES WHERE THE PLANE WAS AT REST. In one case the fire was apparently due to a short circuit, and in the other a seaplane was destroyed when oil on the water around it was ignited from a carelessly discarded match.

Number of Lives Lost in 28 Fires.

	Total	Men	Women	No Data	Pilots	Passengers
Fire in Air.....	19	14	1	4	8	11
Fire Following Crash...	35	32	3	0	14	21
Totals.....	54	46	4	4	22	32

Typical Fires in the Air.

MARLBORO, MASS., AUGUST 24, 1921. A plane caught fire about 200 feet over this town, but the pilot was able to land the plane and extinguish the fire. His passenger was badly burned.

CHICAGO, ILL., OCTOBER 5, 1927. The first trip was being made in a two-seater biplane when a wing broke, following which the plane broke into flames. The pilot was killed.

ROME, ITALY, JUNE 18, 1928. One man was killed, but another saved himself by jumping with his parachute when the military plane which they were flying took fire at about 3000 feet. The man who was killed stayed with the plane too long in an attempt to save it.

NASHUA, N. H., JUNE 17, 1928. A man and a woman, passengers in a plane, were burned to death. The plane caught fire from a leak in the gasoline tank and crashed. The pilot was badly injured.

MITCHELL FIELD, N. Y., MAY 25, 1928. The assistant operations officer was flying at about 3000 feet when he felt a dash of gasoline in his face, fire following. Although he had some difficulty in getting out of his seat when a parachute strap caught on the edge of the cockpit, he pulled the ripcord of the chute, which opened and pulled him free from the diving plane.

WASHINGTON, D. C., APRIL 6, 1928. A naval pilot was badly burned as a result of a parachute jump from a blazing plane. The plane was reported to be equipped with a "sprinkler" system (presumably a carbon tetrachloride pressure-fed system which the Army and Navy have been developing), but it is not known whether the pilot was able to use it or not.

Typical Fires Due to Crashes.

WESTBURY, N. Y., SEPTEMBER 21, 1926. This was a heavily loaded plane taking off for an attempted transatlantic flight. A wheel on the landing gear buckled under the load on striking a bump and the plane careened into a ditch and took fire. The pilot and one passenger were able to get out of the wreckage, but two other passengers were burned to death.

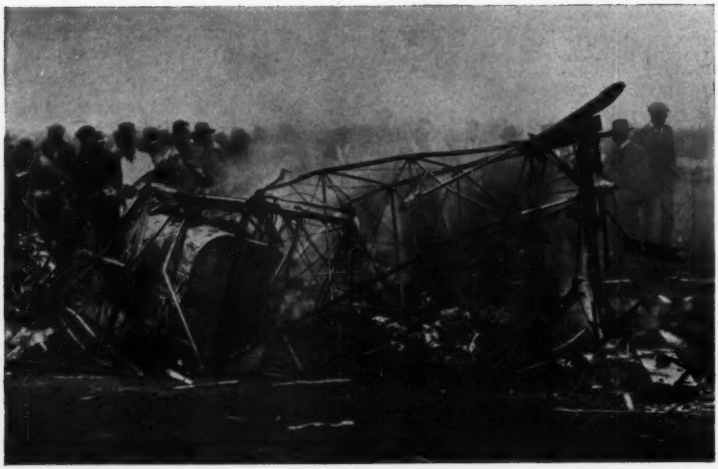
DETROIT, MICH., SEPTEMBER 28, 1927. A small airplane crashed in a garden patch outside the city, turning over as its wheels struck a ditch. Fire followed in which the one passenger was burned to death and the pilot seriously injured. The gasoline tank was ruptured in the crash.

DOUGLAS, ARIZ., MAY 31, 1928. An army air service captain was burned to death in a forced landing. As the plane landed it overturned, the gas tank took fire and the captain was caught in the blaze. A companion was thrown clear of the plane and escaped with injuries.

WESTFIELD, MASS., JUNE 27, 1927. One of five army airplanes was forced down, the plane crashing and taking fire. The pilot and passenger were able to get out and get safely away from the plane, which was destroyed before fire apparatus could arrive.

PURLEY, ENGLAND, JULY 14, 1928. A single engined biplane had been overhauled and had taken off on a test flight with six passengers. After leaving the field it was seen to wabble and then side-slip to the ground, where it crashed. The pilot and one passenger were able to get clear before the fire started. Two of the other passengers were men and two were women. All were trapped in the wreckage and burned to death.

PROVIDENCE, R. I., JULY 26, 1928. Two men flying an enclosed two-passenger plane were killed when their plane took a nose dive to the ground



Underwood and Underwood.

This plane crashed on the golf course at Teterboro, N. J., and was destroyed by fire with the loss of two lives.

from about 100 feet. The crash drove the engine back into the gas tank and the men were burned in the fire which followed.

Fires in Planes at Rest.

ROOSEVELT LAKE, ARIZONA, APRIL 6, 1927. An Italian flyer who had flown across the Atlantic Ocean lost his seaplane when a thoughtless boy dropped a match on oil floating in the water around the plane. The fire on the water communicated to the plane, completely destroying it before extinguishing apparatus could be assembled.

BOSTON, MASS., OCTOBER 5, 1927. A biplane at the airport took fire without warning. The plane had not been in use that day so the fire is supposed to have been due to some short circuit. Before extinguisher could be used the gasoline tank burst, scattering the liquid over the plane. It was completely destroyed.

Airplane Hangars.

While there were records of only 10 fires in hangars and like buildings, the reports were in much better detail than the airplane fire reports. The following summary of these reports should be helpful in indicating the principal fire hazards.

Five of the fires occurred on private or municipal landing fields, three were at air mail fields, and two were on army property. The buildings involved were largely of frame or iron clad construction, and in the majority of cases no adequate fire protection was available.

Fire at Bolling Field, Washington, D. C., December 27, 1927. One of a series of fires occurring at the same field. This hangar served as storage warehouse and officers' club; it was about half destroyed before the fire was extinguished.

Occupancy of Buildings.

	No. Fires
Hangars Used for Storage and Repairs	6
Assembling Planes—Storage of Parts	2
Operations Office	1
No data	1
Total Fires	10

Most of the buildings were hangars of the usual sort encountered around airports, where these are used not only for storage but for many miscellaneous purposes of repair, painting, etc. In two cases, as the table notes, operations involving the construction of planes were under way, the buildings being used for storage of parts, construction work and storage of completed planes with gasoline in their tanks.

Construction of Buildings.

	No. Fires
Frame	5
Steel Frame Iron Clad	3
Wood Frame Iron Clad	1
Brick Walls Steel Frame Roof Structure	1
Total Fires	10

A few of the frame hangars were buildings converted to hangars from barns or other occupancies.

Cause of Fire.

	No. Fires
Unknown	3
Spontaneous Ignition	1
Gasoline Torch	1
Improperly Installed Heating Furnace Smokepipe	1
Boy Threw Match Into Pail of Paint	1
Explosion of Oil Burning Furnace	1
Exposure*	1
Supposed Electric Wiring	1
Total Fires	10

The above table has too few fires to permit any generalization about the cause of fires in hangars. Fires may be expected from the common hazards incident to most occupancies as well as the special hazards due to this occupancy.

Extent of Damage.

No. of Planes Destroyed	No. Fires
None	2
1	2
2-10	3
10-20	1
20-30	1
No data	1
Total Fires	10

Estimated Loss	No. Fires
Under $10,000	2
About $20,000	1
About $50,000	3
About $100,000	3
About $300,000	1
Total Fires	10

The above table suggests that sizable losses may be expected when airplane hangars burn. Much of this loss may be explained by the almost universal lack of fire protection on the premises adequate for the control of the fires in their incipient stages. No mention was made in any of the reports of any attempt to use first aid protection, the assumption being that there was none. In one case a watchman discovered the fire.

Large size chemical extinguishers and a good water supply are needed, together with a local fire brigade which can bring the apparatus into play at once.

As the following table shows, even when a fire department was available, there was not always a water supply.

Fire Protection.

Water Supply.	No. Fires
Some Supply Available	3
No Water Supply	3
No data	4
Total Fires	10

Fire Department.	No. Fires
Fire Department and Water Available	3
Fire Department Used River Supply.	1
Fire Department but no Water	1
No Fire Department Available	2
No data	3
Total Fires	10

*This fire started from a defective oil burner.

As airplane landing fields are not usually near built-up parts of the community, the regular fire department should not be too much depended on, due to the fact that airplane fires spread rapidly due to the gasoline involved. In no case was there noted any attempt to summon the fire department by a fire alarm box, these being lacking. Every airport should have a fire alarm box on the premises to ensure prompt response of the fire department.

Typical Fires in Airplane Hangars.

WESTON, MASS., JUNE 16, 1926. This was a fire in a hangar made from a large barn housing four completed airplanes and 14 others in process of construction. There was gasoline in the tanks of many of these. The fire started in a paint shop in the building from spontaneous ignition and spread rapidly. Fire departments of two villages were handicapped by difficulty of getting water from hydrants 600 feet distant, and sparks falling on near-by wood shingle roofs lessened their opportunity to attack the main fire. The neighboring buildings were saved but the hangar and its contents were entirely destroyed with a loss estimated at $50,000.

KANSAS CITY, MO., FEBRUARY 23, 1927. Fire starting in a frame office building spread to and destroyed a steel frame hangar containing four planes. The fire started from a temporary oil burner defectively installed in a wood fuel heating stove. The oil was fed by gravity from a 500-gallon tank above ground between the hangar and the office. The loss was over $100,000.

WASHINGTON, D. C., JANUARY 26, 1928. The operation office was destroyed by fire starting in a defectively installed smokepipe of a heating furnace. The fire was confined to the building by firemen.

HOOVER FIELD, VA., JULY 3, 1928. This fire was discovered by the night watchman in a big hangar and was spreading rapidly. He summoned the fire department from Washington by telephone, and engines from there taking water from the river were able to save near-by buildings. Damage estimated about $100,000.

SAN ANTONIO, TEXAS, JULY 29, 1928. A large wooden hangar containing aeronautical equipment was burned by fire from a cause that could not be determined.

Mysterious Barn Fires.

By David J. Price,
Chairman, N.F.P.A. Committee on Farm Fire Protection.

The large number of fires of agricultural products ascribed to "spontaneous combustion" is ample justification for a discussion of the subject at a convention of this character. Any one interested in the determination of the causes of fires, particularly on farms and in rural communities, and in devising ways for their prevention, is impressed with the importance of this problem. Using a more common term, "self-ignition," may make clearer just what is embraced in the term "spontaneous combustion."

It is not the purpose to enter into a technical discussion of this subject by dealing with any of the chemical or bacteriological phases. It probably will be of more practical value to confine this presentation to outlining the problem in such a manner as to show its importance and the attention that is now being given to its solution.

Work of the United States Department of Agriculture.

The Chemical Engineering Division of the Bureau of Chemistry and Soils of the United States Department of Agriculture is making a special study of farm fires with a view to the development of control and prevention measures. In this work the department is coöperating with practically all national organizations interested in farm fire prevention. The department has leadership in the work of the Farm Fire Protection Committee of the National Fire Protection Association. The committee, after a careful survey, is of the opinion that the annual loss from fires on farms and in rural communities is approximately $150,000,000, and that about 3,500 lives are lost every year from farm fires. These losses are so great that any national effort to reduce them would be amply justified.

Spontaneous Combustion Losses.

The annual farm fire losses can be attributed to many causes. Spontaneous or self-ignition of hay and other agricultural products is now regarded as one of the principal causes. It has been conservatively estimated that a loss of $30,000,000 a year can be charged to this cause. It may be of interest, therefore, to refer to some of the attention that is being given to this much misunderstood occurrence.

Barn Fires in Vermont Flooded Areas.

The unusual conditions in the Northern Vermont flooded areas, where the water reached the hay mows of hundreds of barns, offered exceptional opportu-

Paper presented before the annual convention of the National Association of Mutual Insurance Companies, Milwaukee, Wisconsin, October 2, 1928.

nities for studies relating to the spontaneous or self-heating of agricultural products.* Observations were made by Department of Agriculture investigators in many barns in the Winooski, Lamoille, and Missisquoi River valleys. Excessive heating set in almost immediately after the flood waters receded, in many cases endangering the houses and other farm buildings. The observations on spontaneous heating in Vermont barns can be summarized as follows:

1. The hay was covered with water ranging from one-half foot to 17 feet.

2. In every pile of wet hay observed some "heating" had taken place, many to the point of being considered dangerous.

3. Heat was generated in the bottom layers of the piles, and escaping up through the hay led to the production of drafts of hot gases or "flues" that rose to the surface.

4. The large quantity of moisture carried with the hot gases from the lower layers was condensed on the upper, cooler hay, or in the air above. Many hay piles had been soaked throughout by the falling condensed moisture.

5. In removing the hot hay from the barns one farmer observed charred materials.

6. The most marked evidence of excessive heating was observed by the farmers on the second and third days after the recession of the flood waters.

7. A clear-cut case of spontaneous ignition occurred near Middlesex, Vermont. This farm was in a narrow portion of the Winooski River Valley, where the flood waters rose exceptionally high. The barn contained about 50 tons of meadow hay and a little alfalfa.

The hay had been kept in a bay in the rear of the barn and rested upon boards laid flat on the ground. The contents of the hay consisted of:

About 2 feet of the previous year's hay (1926).
About 6 inches of first cutting alfalfa (1927), which had rotted somewhat in the field, but which was dried before being stored in the barn.
About 45 feet of good meadow hay.
About 6 inches of good, second cutting alfalfa (1927).
About 6 inches of rowen on the top.
There was also a small pile of old dry straw on the barn floor.

The flood waters covered 17 feet of the pile of hay and most of the straw. No heating of the hay had been noticed before the flood, but considerable steaming was in evidence 24 hours after the waters had receded. The crest of the flood occurred early on Friday morning, November 4, 1927, and the barn burned between four and five o'clock on Monday afternoon, November 7, or about two days after the flood waters receded. On Sunday morning much heating had been noticed, and on Monday a distinctly charred odor was observed before the fire started. The barn burned to the ground, and a silo, close by, fell over and was destroyed. It is interesting to note that the barn and hay stood in from three to five feet of water when the fire broke out.

*Science, Vol. LXVII, No. 1734, page 322.

In connection with the Vermont studies a number of farmers living near the Canadian border were visited. Several of these farmers claimed to have had marked success in stopping "spontaneous heating" of hay by the application of large quantities of salt. The urgent need for extensive research upon the problem of the "spontaneous heating" of farm products was emphasized by the lack of scientific knowledge with which to meet the situation in Vermont.

A Case of Spontaneous Ignition in Stable Manure.

Department of Agriculture specialists have reported an observed case of spontaneous ignition in stable manure at the Arlington Experiment Farm at Rosslyn, Virginia.* Manure for fertilizer purposes had been hauled from a near-by cavalry station and placed on the farm grounds in an open plot. As the manure was unloaded the horses and wagons were driven over the pile and the load of manure was deposited on top. The custom had been to "cure" the manure from one to three years before spreading. The first loads had been deposited some two and a half years before and the mass had grown to a pile about 200 feet long, 50 feet wide, and from 1 to 20 feet high. Moderate heating of the manure had been accepted as an essential part of the curing, although fire had not formerly occurred.

Before September 9, 1925, the date of the fire, the weather had been warm, ranging from 87° to 95° F. There had been no heavy rains for at least two weeks. Daily additions had been made to the pile, and although the mass was known to be excessively hot the condition was not considered dangerous. Fire broke out during the night of September 9 and was discovered by the night watchman. The flames quickly spread over the entire west side of the pile. Water was applied from pails and the flames were extinguished. Within a few hours, however, fire again broke out along the same side of the mass.

The following afternoon, September 10, fire broke out on the opposite or east side of the pile. When this fire had been put out an inspection of the stack revealed so many hot areas along the edges that the entire side was removed under frequent sprinkling with water. It was interesting to observe that when a forkful of material from one of the hot sections was removed and spread upon the ground the straw was hot and steaming. About a minute later the steam changed to smoke, which increased in density until after about three minutes the material glowed a fiery red. Exactly the same conditions appeared in the stack adjacent to the spot from which the material had been removed.

This very definite observation, as well as many others of a similar type, indicates the possibility of spontaneous ignition of manure piles which may in some instances be closely related to unexplained barn fires.

*Journal of Agricultural Research, Vol. 36, No. 5, March 1, 1928, pages 481-485.

Spontaneous Ignition in Hay Mows and Stacks in Canada.

Fire Marshal E. P. Heaton of Toronto, Ontario, has given considerable attention to the subject of spontaneous combustion in barns, and has issued several publications on this subject. In a three-year period more than 400 barn fires in the Province of Ontario were investigated.† One hundred and eighty of these fires occurred in one season. In this investigation sufficient evidence was obtained to warrant the conclusion that "at least one-half of these fires have been directly and solely caused by spontaneous heating."

The conclusions by the Ontario fire marshal from this investigation of 400 barn fires are classified by him as follows:

1. Concerning the structure of the barn.
2. Concerning the farm crop.
3. Concerning farm machinery.
4. Concerning the character of the fires.

Concerning the barn structure. The modern bank barn with close siding, frequently battened on the outside with inadequate gable and roof ventilation, contributes to spontaneous ignition. (This conclusion indicates the importance of adequate barn ventilation.)

Concerning the crop. 1. The present crops, now consisting largely of alfalfa and clover hays, cannot be properly cured and in condition to be housed, as was done in former days with crops which consisted principally of timothy.

2. Crops upon which rain has fallen should receive extra care, and should not be housed until thoroughly and completely dry.

3. After the crop is placed in the barn no water should be permitted to fall on it or be absorbed by it.

4. On account of lack of space, grain in the sheaf, baled hay and straw are often put above the hay in the mows, pressing the hay and preventing the escape of vapors and gases.

5. The old-time custom of salting hay in the mow has largely disappeared. This is regarded as unfortunate, as salting has been an accepted means for retarding combustion.

6. Stacks of hay or straw should never be built upon old footings, particularly when manure has been dumped thereon.

Concerning farm machinery. 1. New types of machinery for expediting the handling of the crops have been introduced.

2. The hay loader is frequently used to take up the crop from the windrows without cocking or coiling, which is regarded as an indefensible practice.

3. The speeding up of haying by the use of machinery necessarily results in imperfect curing and is favorable to spontaneous combustion.

†"Spontaneous Combustion in Hay Mows and Stacks," issued by Fire Marshal of Ontario, 1921.

Concerning fires. 1. Nearly every county in Ontario during the year in question (1921) had experienced many "mysterious fires" of this character.

2. Most of the barn fires occurred between 6 A.M. and 9:30 P.M. This is not regarded by the fire marshal as a favorable time for incendiary fires.

3. The months immediately following harvest or threshing are the ones in which most of the assumed "mysterious fires" occur.

The results of these investigations by the fire marshal of the Province of Ontario are a very valuable contribution to our knowledge on the subject and indicate that many of the 400 fires studied can be ascribed directly to the spontaneous ignition of hay.

Survey of Barn Fires in Pennsylvania.

The Pennsylvania State Bureau of Fire Protection, in coöperation with the Pennsylvania State College, made special studies of mysterious fires in that state.* The report of this survey states that "The farmer has been advised repeatedly as to the numerous fire hazards common to the farm, with but a single exception—spontaneous combustion. Spontaneous combustion has long been regarded as a marvelous and deeply mysterious phenomenon, something to be left strictly alone. The primary object of this survey was to bring light upon this subject and explain to the farmer the manner in which fire from this cause may be avoided."

The loss of farm property by fire in the State of Pennsylvania had increased from $2,796,871 in 1918 to $3,293,863 in 1924. In 1920 the farm fire loss in Pennsylvania represented 12.6 per cent of the total fire loss of the state. The value of all farm buildings, live stock and machinery was put at 6.7 per cent of the total value of the property in that state which was subject to loss by fire. Eight hundred and forty-five barns were destroyed by fire in one year alone (1920).

In this special survey the studies were made of the barn fires in the large alfalfa-producing sections. Six definite cases of spontaneous ignition are reported, five of which occurred in first-cutting of clover and alfalfa hay, and one in second-growth clover and timothy. Cases were also found where the hay had ignited, but owing to lack of air, ignition and subsequent destruction of the barns were prevented.

Studies in Switzerland.

As the result of a contest initiated by the Association of Cantonal Fire Insurance Companies in Switzerland, studies have been made on the spontaneous combustion of hay. The results of these studies have been published in detail by G. Laupper of Zurich, under the title "The Losses to Agriculture Resulting from the Spontaneous Combustion of Haystacks."† Laupper states

*Survey of Farm Fires, by Bureau of Fire Protection, Pennsylvania State Police, Harrisburg, Pa., December, 1925.

†Matériaux pour l'étude des Calamités, July-September, 1926, pages 112-136.

that sixty years after the death of Christ, Pliny wrote "The cut hay must be turned about in the sun and should be dried when it is stacked. If this is not carefully observed a mist will be seen rising from it in the morning and it will soon be ignited by the sun and burn up." The statistics compiled in Switzerland by the Board of Directors of the Association of Cantonal Fire Insurance agencies resulted in the following conclusions:

1. That spontaneous combustion as the cause of fires is of far more frequency and covers a much wider territory than is generally supposed.

2. The fact needs to be widely known that we have to face a real calamity which deserves the closest attention of agriculturists.

These barn fires in Switzerland occurred in harvest season and declined as the winter season approached, which conditions are similar to those under which the fires of this character occurred in both Canada and the United States.

Control Measures.

In considering this subject it is only natural to inquire as to what may be done to control fires of this kind. The research work now under way in the Department of Agriculture is being planned with a view to the development of practical measures. Special studies involving both chemical and bacteriological aspects of the problem have been undertaken, and experimental work on a practical basis has been planned.

In a special leaflet entitled "Preventing Farm Fires," the Farm Fire Protection Committee of the National Fire Protection Association makes the following recommendations for the prevention of fires from spontaneous ignition:

"Thoroughly cure hay, pea vines and other roughage before these are stacked in barns. Do not allow horse manure to accumulate in large piles in stables or against buildings. Where slightly damp hay is stored, a sprinkling of salt is useful to retard fermentation. Use from three to ten pounds of salt per ton of hay, according to its dampness.

"Uncured hay continues to live for some time after it is cut, and heats when stacked in large piles. Also the fermentation of bacteria, yeasts and molds, which increase rapidly in horse manure, uncured hay, green pea vines and other damp roughage, generates heat, which accumulates at the center of a heavy mass of these materials, eventually to an extent such that the small amount of air that filters into the pile can cause ignition."

Importance of Co-operation.

In this research work on the spontaneous heating or self-ignition of agricultural products, the Chemical Engineering Division of the Bureau of Chemistry and Soils solicits the coöperation of the farm associations, insurance organizations, and all interested agencies. It will be helpful for the bureau to receive prompt reports of fires of this character, together with a record of any direct experiences in connection with this important subject, about which more knowledge must be acquired before effective control measures can be devised. The problem of spontaneous ignition not only is related to farm products, but extends into practically all lines of industry and results in extensive economic losses. It is a problem of national importance and one that justifies thorough scientific research.

Harahan Bridge Fire, Memphis, Tennessee.

Report by the Tennessee Inspection Bureau (Member N.F.P.A.).

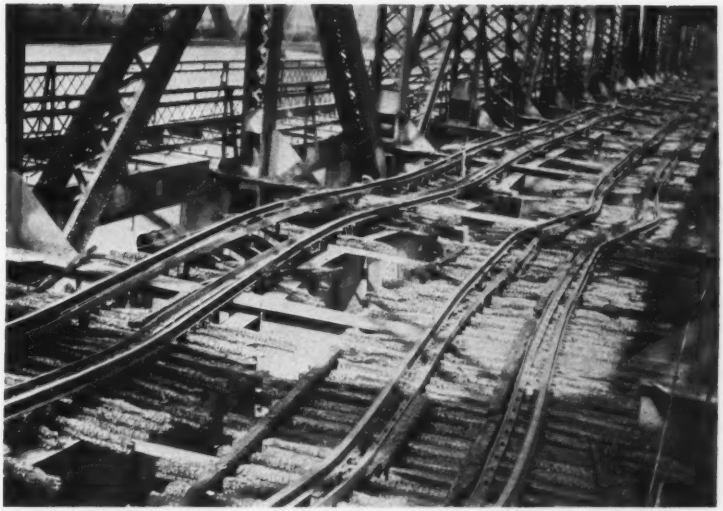
Fire on September 17, 1928, destroyed the timber decking on the two eastern spans of the Harahan bridge at Memphis, with a property loss estimated at more than $200,000 and causing an economic loss due to the suspension of traffic which will probably equal and perhaps exceed the actual damage by fire.

The bridge, built in 1916 at an approximate cost of $3,500,000, is owned by the Arkansas and Memphis Railway Bridge and Terminal Company. The railroad tracks are used jointly by the Rock Island, Missouri Pacific, and St. Louis-Southwestern railroads. The bridge is of cantilever type, steel, and consists of five spans carried on four masonry piers and the two abutments. Its total length is 2,649 feet, with an approach of similar construction on the Arkansas side 2,363 feet long. On each side of the middle section used by the railroads and outside of the main trusses is a vehicular and pedestrian roadway supported by steel girders fastened to the main structure of the bridge. The floor of each roadway was constructed of heavy oak planks spiked to heavy wood joists that were bolted to the steel girders. The railroad tracks were supported on creosoted wood ties bolted to steel beams.

This bridge is the only vehicular bridge across the Mississippi River south of St. Louis. A considerable number of national highways converge to it, and as the vehicular traffic is totally suspended the congestion at each end of the bridge is tremendous. The Highway Department of the State of Tennessee, in an effort to cope with the situation, hurriedly put into operation three free ferries. It has been reported that the Highway Department is spending more than $500 per day keeping these ferries in operation, and that in one day more than 1,000 motor cars and 2,500 passengers were ferried across the river.

The fire fighting equipment at the bridge was suitable only for small fires. Water barrels, pails and sand buckets were provided about every 150 feet at the side of the railroad tracks. Two 1½-quart extinguishers were kept in the watchmen's shanty at the Memphis end of the bridge, and one 1-quart extinguisher was carried by the watchman on patrol. These had often been used in extinguishing sparks or small fires. A railway push car equipped with two 40-gallon soda-acid extinguishers was located about 200 feet from the Memphis end. A three-way hydrant nearly two blocks away was the nearest source of supply from city water mains, and the west end of the bridge on the Arkansas side had no protection.

Two watchmen, not specially fitted or trained, were always on duty. One remained in the watchman's shanty while the other patroled the bridge and



The Harahan Bridge after the fire of Sept. 17th, 1928. This steel structure had enough woodwork in the bridge flooring to make a serious fire. The central section was used for railroad tracks and two outer sections for vehicular traffic. One of these may be seen at the left of the picture, with the timber flooring completely burned away. (See also frontispiece.)

steel viaduct of the railroads over the Arkansas bottomlands. The combined length is about one mile and a trip required a half hour each way and included a half hour's stay at the Arkansas end. The only means of sending in an alarm was to walk to the Memphis end and use the private telephone to notify the bridge dispatcher, who could in turn telephone the fire department. The practice of the watchmen was to use first aid equipment on a fire and then, if beyond control, they would give the alarm.

The fire was discovered about 1:30 P.M. by a passing motorist, who discovered smoke on the north roadway, east of the second pier at the Memphis end of the bridge. He notified the watchman at the shanty, who went with the motorist to take a look, inasmuch as there is smoke frequently about the bridge. In the meantime another motorist reported it. On observing that the bridge was on fire the watchman returned to the shanty and secured the 1½-quart extinguisher, which he emptied on the fire. On his return he told the other watchman, who had arrived from the other side, that he had called the bridge dispatcher, and both watchmen helped a section gang roll the hand car to the fire, where the two 40-gallon soda-acid extinguishers were emptied but failed to check the flames. By this time the fire was burning fiercely, and quickly spread across the bridge toward the Memphis end. (The watchman later told the bridge dispatcher that they had used the hand car before he

Furious burning of the bridge flooring. Difficult of access for fire fighting operations.

telephoned. The dispatcher telephoned the fire department at about 1.45 P.M.)

About this time a fire department pumper arrived on the north roadway in response to two telephone calls (one from a near-by office and one from an unknown party) received about 1:37 P.M., stating that the Harahan viaduct was on fire. The Harahan viaduct is a large wooden structure beyond the bridge in Arkansas without any protection, and Chief Moore at headquarters was making arrangements for water tank wagons. On finding that it was the bridge the captain of the pumper sent a man to the nearest city telephone to notify the chief, and laid hose lines from the nearest hydrant two blocks away. At 1:44 P.M. another pumper was dispatched to the fire, and on the arrival of the chief two more were summoned. Four hose streams were used, supplied by the pumpers through lines of considerable length. The captain of the first

The heat was sufficient to soften and distort the steel members, as shown by this typical detail view.

company stated that 300 feet of roadway was involved when he arrived on the scene.

The U. S. Government fleet office on the Arkansas shore was notified by telephone at about 1:45 P.M. and sent one and then a second boat having fire fighting equipment to fight the west end of the fire. Two hundred employees, under the fleet fire marshal, used a 40-gallon foam extinguisher and, aided by a favorable wind, cut away twenty to thirty feet of each roadway near the west side of the fire. A railway bucket brigade from locomotives was also used. A two-inch hose stream from the boats was then placed in operation and with the help of a second hose stream brought the fire at this end under control. Later the first line broke, but the urgent need of it had passed. About 4 P.M. a fire department pumper on a barge was towed down from an uptown wharf and a hose line put into operation by firemen on this side and used until 5:30 P.M.

Meanwhile, on the Memphis end the firemen, with their four streams, prevented further spread of the fire, but because of a high wind and the large amount of creosoted timber had a very stubborn fire to extinguish. They fought their way across until they met those on the west end. The chief and one pumper remained until 8:30 P.M.

The greatest amount of damage occurred between the first and second piers, although the anchor span was somewhat damaged. All roadway flooring and ties were destroyed, and most of the horizontal steel members buckled badly from the intense heat. The large girders running across the railroad portion and tying in with the vertical and diagonal truss members and running lengthwise between these truss members were apparently not damaged.

The beams between these girders, which carried the ties, and the large outermost beams and girders, which supported the roadways, buckled badly.

The exact cause of the fire is not known. Among the most probable causes are sparks from locomotive, sparks from steamboat on the river, and lighted cigar, cigarette or match thrown from automobile or dropped by pedestrian. The rapid spread of the flames, once started, was made possible due to the large amount of dry wood in the structure of the bridge subject to the hazards mentioned above under causes, with watch and alarm service poor, as noted, only fair first aid equipment, no water supply readily available, and, as we have shown, prompt notification of the fire department was not considered urgent.

The heavy loss from this fire may be said to be due to:

(1) Inadequate watchman service.
(2) Almost total lack of adequate means of reporting fires to the city fire department without delay.
(3) Application of first aid appliances before calling assistance from city fire department.
(4) Lack of standpipe protection for entire bridge.

This fire again illustrates the damage suffered by all steel structures when subjected to intense heat, and indicates the importance of holding combustible material used to a minimum. It emphasizes the importance of trained watchmen and adequate alarm service, that the fire department may be called promptly. It demonstrates the value of a fireboat in fighting a bridge fire, even though the boats used were not specially equipped for this purpose and might not have fully protected the bridge had the direction of the wind been different. It clearly indicates the value and need of an iron pipe (dry with control valve) extending the length of the bridge, with staggered outlets and hose stations at frequent intervals.

Epitaph on an Obscure Person.

Stranger, these ashes were a Man
Crushed with a grievous weight.
He had acquired more ignorance than
He could assimilate.

—WILLIAM WATSON.

Film Vault Fire, Kansas City, Missouri.

Report by Missouri Inspection Bureau (Member N.F.P.A.).

Improper storage of films in a sub-standard vault was the principal factor in a Kansas City, Missouri, fire on August 4, 1928, which caused a loss estimated at approximately $100,000 to the building of origin and approximately $20,000 to the adjoining structure. In addition, the absence of municipal fire alarm boxes in the vicinity caused considerable delay in sending in the alarm and fire companies responding on second alarm were seriously delayed by automobiles blocking the streets in the vicinity of the fire.

The building, located at 2449-51 Charlotte Street, was occupied by the United Film Ad Service, Inc. as a studio in which advertising films were photographed, developed and printed. The basement was used for developing, printing and assembling of film and the 1st floor for offices. The rear section was devoted to studio purposes in which interior scenes were taken.

The building was of fire-resistive construction, one story with basement (mostly above grade) 130 ft. x 37 ft. Floors and roof were reinforced concrete joist construction except rear 45 ft. which had a roof of 2 in. concrete on unprotected metal lumber. The rear 45 ft. was separated from the remainder of building by a 12-in. fire wall with two openings protected by single three-ply, tin-clad automatic fire doors. One stairway in rear section was open basement to 1st, and one stairway in front section had a 6 in. tile enclosure with a single two-ply tin-clad automatic fire door. Two adjoining film vaults of reinforced concrete projected from north side of building on the basement level with openings into basement protected by double automatic tin-clad fire doors. One vault was 8 ft. wide x 20 ft. long x 8 ft. high, and the other 17 ft. wide x 20 ft. long x 9 ft. high. Combustible shelving and fixtures were used in both vaults. Vaporproof globes were installed on all lights. Ventilation was secured by means of a metal stack 20 in. in diameter and about 20 ft. high on each vault and through steel sash tilt-type wired glass windows in wall. Stock consisted of short reels mostly in the open and without individual metal containers. Both vaults were filled to capacity at the time of the fire. Openings to the film vaults were exposed by a sheet metal shop of steel and brick construction with wood roof 8 ft. distant on the north.

Story of the Fire.

The fire was discovered about 2:25 P.M. by an employee working in the basement who saw flames coming from the outside window of the smaller film vault. He ran to the door of the vault and saw the interior full of smoke and flames. He slammed the fire door shut and notified the other employees

in the basement. Only three men were working in the building, as the plant closed at one o'clock Saturdays. Another employee noticed that the fire door had not closed completely and ran over and slammed it tightly shut and all then left the building. A foreman working in the outside yard was notified and he attempted to carry a hand extinguisher down the basement stairway, but was forced to withdraw by the heavy smoke issuing from around the edges of the vault door "as if under pressure." Within a few minutes the adjoining vault became involved, and shortly thereafter, a dull explosion took place which blew off the roof of the rear section and involved the entire building in flames. The flames shooting from the windows of the vaults quickly ignited the overhanging eaves of the sheet metal shop 8 ft. distant and in a very short time the entire roof of this building became involved.

By this time the fire department had arrived, the alarm having been received over the telephone, probably from an outsider. The first efforts were directed to saving the sheet metal shop, as the film building appeared doomed. Additional companies were immediately called, some of which were seriously delayed by autos blocking the streets in the vicinity of the fire. One company claims to have been delayed thirty minutes in reaching a hydrant and laying their line. Eight hose streams were used from seven pumper and hose companies and the fire was extinguished in about two hours.

The absence of municipal fire alarm boxes in this district caused considerable delay in transmitting the alarm. The explosion in the building is said to have crippled a number of telephones in the neighborhood, which caused additional delay in sending in the second alarm.

The cause of the fire is a matter of conjecture. The most probable cause is that a spark from some source was introduced into the open window of the film vault and ignited the open film stock. Employees were positive in their statements that no smoking took place in the vaults. Another cause that is possible, though not probable, is the ignition by the sun's rays of the open stock adjoining the window which was uncolored glass. Although the vault window faced north, the facing wall of the adjoining building was all of steel and glass which reflected the rays into the vault almost as strongly as the direct rays. The temperature was very hot the day of the fire and a ray shining through a flaw in the glass might have caused ignition.

The explosion which blew the roof off the rear section was undoubtedly caused by the ignition of the flammable gases and smoke which filled the building. Very little evidence of fire was seen in the rear section, although the front section, with its pyroxylin stocks and office records, suffered considerable loss by the fire.

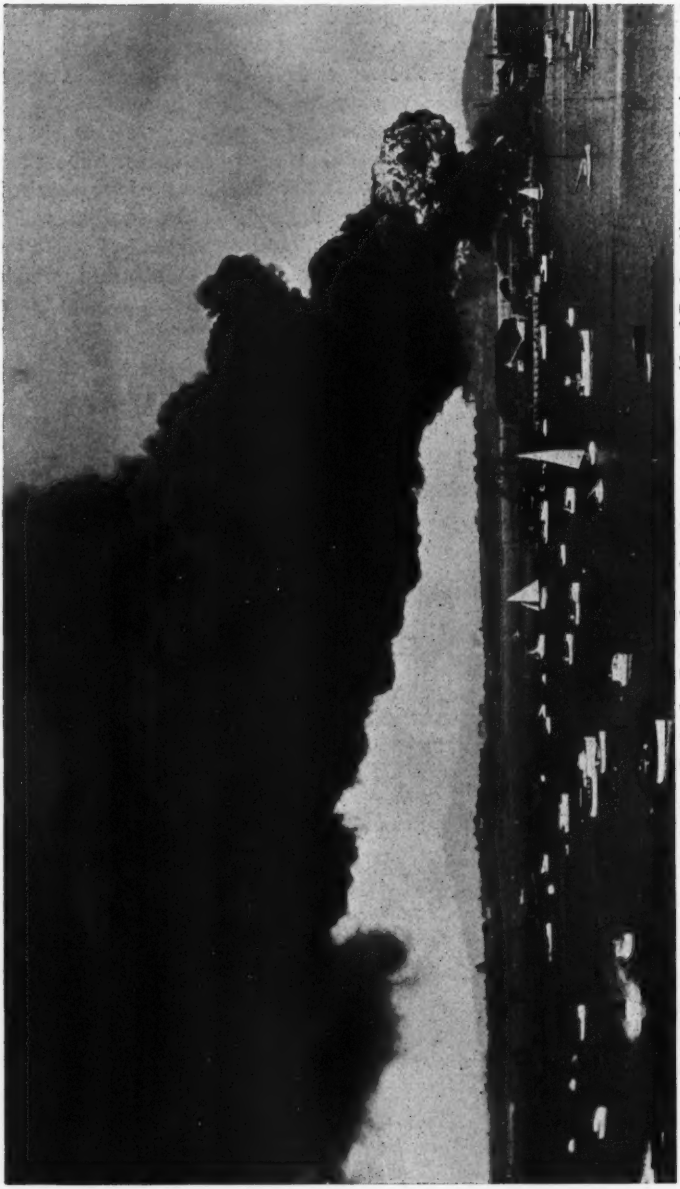
The damage to the film building was considerable, the roof of the rear section being blown off and the concrete in the front section spalled. All films in the vaults and a large amount of the contents in remainder of building were destroyed. The adjoining building, which had a wood roof on unprotected

steel trusses, suffered about a 50% loss to building and considerable damage to finished products and raw stock.

The fire has several important lessons to offer, chief of which is that the recognized standard for the handling of nitrocellulose film cannot be flagrantly violated with impunity. The vaults in this building were glaringly non-standard. The open windows presented a standing invitation to all the stray sparks in the vicinity, and the open stock adjoining the windows promised a warm reception to any that entered. The non-standard ventilators of insufficient area caused the gases to be forced out into the building where their ignition resulted in the destruction of the rear section. Automatic sprinklers should have been provided throughout the basement of this building; the loss suffered on the uninsured film would have purchased several sprinkler systems.

CAUSE AND EFFECT

Providence Journal.



No. 1. Petrol Store Fire, Auckland, New Zealand. Taken from foreshore on western side of Reclamation Area, showing general position and spectacular nature of fire.

Auckland, New Zealand, Petrol Store Fire.

Report by R. G. Butcher,
Deputy Chief Inspector of Explosives, New Zealand.

Fire in the Petrol Store of Messrs. Winstones, Ltd., Beaumont Street, Auckland, commenced about 1:30 P.M. on Sunday, April 1, 1928, and burned for nine days.

Description of the Building.

The store was situated in the northwest corner of the reclamation area in Freeman's Bay. The building was constructed of 14-inch brickwork and was originally used by the Coromandel Granite Co. for cutting and dressing of stone. It was well built and had a floor of concrete and roof of wood and iron. Some years ago it was converted into a dangerous goods store by Messrs. Winstones, Ltd., to accommodate overflow stocks of petrol for the large oil companies and also stocks imported by smaller firms dealing in cased petrol.

The store was at first divided into four compartments with dwarf concrete walls 3 ft. high and expanded metal partitions above these reaching to the roof trusses. The original intention was to use the driveway from the Beaumont Street doorway through the store for horse-drawn vehicles, and work the compartments from inside the building. The doorways at either end of the compartments were subsequently silled up with concrete to a height of 3 ft. to provide additional storage area, and the store was operated from the doorways by means of gravity runways, and further expanded metal partitions were erected. The store as finally arranged had, therefore, five independent enclosures with concrete walls 3 ft. high. The store was kept under the supervision of a storeman employed by Messrs. Winstones, Ltd., but several compartments were operated separately by the occupants by means of external doors.

At the back of the building was a leanto shed constructed with walls of coke-breeze concrete blocks divided into two compartments and intended for use as repair and soldering room for damaged tins. The regulations under the Explosive and Dangerous Goods Act require an isolation distance of not less

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NOTE: This report from our New Zealand member throws several interesting sidelights on current practice with respect to oil storage in that part of the world, where gasoline is to a large extent handled in tin cases, crated, and in drums or barrels, rather than in bulk. Some of the terms used in this account may be unfamiliar to some American readers. "Petrol" is the British term for gasoline. "Coke breeze" blocks are a concrete block using coke screenings as aggregate. This is a building material in considerable vogue in Great Britain, but not used to any extent in the United States and Canada.

This report makes no mention of the use of foam, or any extinguishing medium other than water. It would appear that a fire of this type might have been readily handled by means of foam hose streams.—ED.

than 50 ft. to be kept between this type of store and the nearest protected work (which includes any occupied building), and the store complied fully with this requirement, the nearest building in occupation being Mason Bros. premises at the back of the store, situated 57 ft. away. The yard at the back was surrounded with a corrugated iron fence about 7 ft. high.

At the time the fire occurred buildings of the Atlantic Union Oil Co. were in course of erection, and the section between Messrs. Winstones' store and these buildings was occupied as a storage and working area in connection with the building operations. Immediately alongside the wall at Messrs. Winstones' store was situated a stack of steel piping for the oil lines to the tanks, and a number of drums of bitumen. The general character of the surroundings and the fire at its maximum height is shown in photograph No. 1, which is taken from the waterfront on the western side of the reclamation area.

Circumstances of the Fire.

The fire occurred about half past one on Sunday afternoon, April 1st, 1928. The store was last open prior to the fire about mid-day on Saturday, and Messrs. Winstones' storeman, who was present at the time, stated that only a few cases were removed on the Saturday morning and everything was in order when the store was closed about mid-day.

The store contained the following stocks:

42,628 cases petrol (containing 8 gallons each).
4 cases containing 400 lbs. ether.
13 cases turpentine.
41 cases kerosene.
2,465 light steel (single-trip) 45-gallon drums of petrol.
20 heavy galvanized steel 45-gallon drums of petrol.
89 45-gallon drums lubricating oil.

In the repair shed referred to above was stored the following:

49 cases of turpentine.
62 cwt. calcium carbide.
12 90-gallon drums of methylated spirit.
1 hogshead methylated spirit.
5 90-gallon drums of wood naphtha.

This latter stock should have been in the main store, but as it happened its presence in the repair shed did not affect either the cause or the result of the fire.

The fire was first reported by the watchman for the Atlantic Union Oil Co.'s premises adjoining. This watchman stated that he first observed smoke at the back of the store and went into the yard from the Jellicoe Street side to investigate. He states that when he arrived the fire was burning in the compartment on the southwest corner alongside the door. He ran to the telephone situated in the wooden shed behind the Atlantic Union Oil Co.'s office and notified the fire brigade. When the brigade arrived they found that the cases

No. 2. Showing burst of flame and drum thrown out of store by bursting of containers. Photograph taken from southwest of building.

were burning briskly alongside the door referred to. They broke open this door and got hose leads to work. They also broke open the door leading to Beaumont Street and carried leads across the cases in the store from this point. The fire had by this time got so big a hold that the firemen were soon driven out of the building.

It will be seen from the photographs that the fire soon reached dimensions rendering it impossible for the brigade to do anything except protect surrounding properties. During the first 18 hours engines were used, pumping water from the harbor, and a number of hose leads were used to throw water into the store and also to cool the outside of the walls of the building. It is doubt-

No. 3. Taken from north side about 45 hours after fire started, showing walls partly collapsed and upper part of eastern wall leaning outwards.

ful if this water had any effect on the fire except possibly to increase the rate of burning due to the additional currents of air, and it is also questionable whether the cooling of the outside of the walls would not tend to assist the disintegration of the cement binding. The fire continued with gradually decreasing violence and burned itself out nine days after it started.

The Result of the Fire.

The fire resulted in the complete destruction of the store and contents. For the first 18 hours it burned with extreme violence and, as will be seen from photographs Nos. 1 and 2, which were taken during this period, was of a highly spectacular nature. A considerable number of explosions occurred, owing to the bursting of the drums stored in the building. The effect of these explosions was to throw both drums and tins to a considerable distance into the air and to scatter them over a radius of approximately 45 ft. around the store.

The explosions were apparently of two types. In one case the drum burst presumably at the top and the overlying burnt-out containers were thrown into the air. This was evident from the fact that the containers were in many cases red hot on reaching the ground. An example of this type is shown in photograph No. 2, which shows a drum in the air with one of the blown-out ends alongside it. Another type of explosion also occurred in which the bursting was probably at the bottom of the drums. The latter were in these cases propelled in rocket fashion into the air.

A distressing fatality occurred as the result of one explosion of this latter type. At the time three firemen were employed about 25 ft. from the south

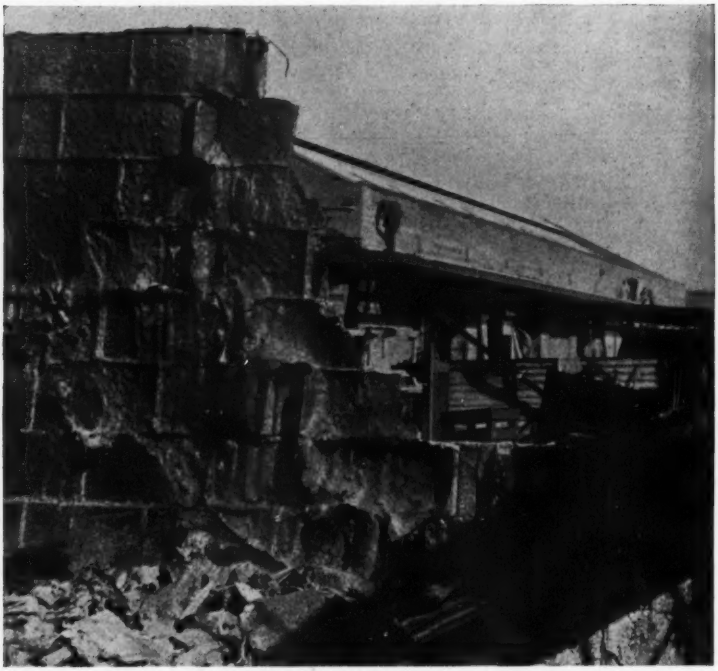
wall of the store directing a stream of water on the brickwork of the south wall. A drum was thrown into the air and the contents scattered over these men, one of whom was so badly burned that he died the following day. The wind was blowing from the south, and prior to this accident no drums had fallen on the south side of the building. No liquid petrol had previously been thrown outside the store and the position was not considered hazardous at the time. With this unfortunate exception no serious damage was done by the fire except to the building and contents.

The roof of the building was burned through in a short time after the fire started. The store was fairly full at the time, and the roof rested on the upper tiers of cases and did not in any way damage the wall when it fell in. The only point at which outflow was reported was in the southeast corner of the building, where a toilet is located. This latter compartment was, owing to some misunderstanding, constructed with inner walls of 4½-inch brickwork only. These walls were completely disintegrated by the fire and there is some evidence that a slight leakage of liquid occurred at this point about eight hours after the fire started.

The walls of the building were not seriously affected during the first 18 hours of the fire. From that time onward the walls broke down fairly rapidly, and by the time the fire had been burning 24 hours a considerable portion of both the northern and western walls had fallen—all the brickwork falling outwards. By this time, however, the fire had burned down to a comparatively low level in the store, probably not more than 4 ft. above the ground. The violence of the fire had decreased considerably by the end of the second day, the explosions of drums had practically ceased. Photograph No. 3 shows the conditions existing 45 hours after the fire started.

The fire continued burning with decreasing violence until the ninth day, and during this period the walls gradually crumbled until at the end only the east wall and a portion of the west wall supported by the repair shed were left standing at about half height. Practically the whole of the northern and southern walls had collapsed. When the store was cleared after the fire it was found that the concrete dwarf walls, referred to above as forming the store sub-divisions, were in quite satisfactory condition. The condition of the containers after the fire is shown in photograph No. 5.

With the exception of the small leakage in the southeast corner referred to above, there was no outflow of petrol from the store during the fire. This is a very satisfactory record, and it is also satisfactory to note that the outer walls, though of brick without bonding, did not fall *en masse*, but broke off in sections from the top as the fire burned down in the store. The effect of the fire was to expand the walls at the top, and after the fire the walls were leaning outwards about 3 to 4 inches out of plumb, the reinforcing rods in the sill at the top of the wall being drawn at the corners.



No. 4. Inside of reconditioning shed after fire, showing melting of coke-breeze concrete walls.

This is what might be expected in a fire of this character occurring in a building of non-combustible construction. The great quantity of air required for combustion is available only from the top of the store after the collapse of the roof, and the major heat is therefore constantly at the top of the fire.

The expansion of the brickwork at the top of the walls is sufficient to account for the gradual collapse of a wall built without bonding materials. It will be seen in photograph No. 3 that the upper part of the eastern wall is leaning outwards at a considerable angle. Our experience would indicate that while reinforced concrete frame work is desirable it is not essential to safety in the storage of petrol.

Reference has been made to the fact that a quantity of flammable liquid was stored in the repair shed at the back of the main store. As noted above, the walls of this shed were of coke-breeze concrete blocks, and the effect of the fire was to melt these blocks completely for about half the wall area. The partition wall between the two compartments was melted down to a height of about 4 ft. This effect is clearly shown in photograph No. 4.

No. 5. Taken while store was being cleared, showing condition of containers after the fire. In this photograph may be seen both the light "one trip" drums and the standard heavy drums.

A noteworthy fact in connection with this fire is that the bursting of the steel drums threw clouds of large sparks—some of them being practically burning brands—from the woodwork of the cases into the air, and these were carried a considerable distance before falling.

Cause of the Fire.

There is no direct evidence available as to the cause of the fire. The building was not fitted with electric light installation and there were no fires in the vicinity of the building from which sparks could have reached it. There were several windows in the western wall, but no cases were stored within 12 ft. of any glass, and the time which had elapsed since the store was opened renders it extremely unlikely that anything could have been smouldering in the building. The inspector for the Auckland City Council visited the store on the Friday afternoon before the fire and everything was then in perfectly satisfactory condition. A complete inspection was made to ascertain what space was available for a shipment of petrol which was arriving on the following Monday. The store was only open for a very short time on the Saturday morning, and under the supervision of the storeman, who is a reliable man.

There is therefore little doubt but that the fire was caused by some interference with the store from the outside. Inquiries have been made by the police department, and there are suspicious circumstances indicating malicious origin of the fire, but the evidence is not sufficient to warrant a prosecution of the individual concerned. It may, however, reasonably be assumed that the store was set on fire.

Lake Superior Mine Fires.

By F. C. Gregory,
U. S. Bureau of Mines.

Metal-mine fires occur frequently and are so full of possible danger to life and property that the subject of fire prevention is of continuous interest to everyone connected with mining. A review of the fire record of the Lake Superior district, noting the frequency of the fires, their causes, and the fire prevention methods employed, should be of benefit to all. It is the purpose of this article to consider as briefly as possible some of the fires that have occurred, their chief causes, and the fire prevention measures and fire fighting methods which some of the operating companies have adopted.

Changed methods of mining and fire protection methods have in recent years effected a change in the causes and location of underground fires. To bring this out, the fires are divided into two groups—those before 1917, and those occurring during the period 1917-28. The earlier fires are mentioned only briefly to emphasize the changing conditions.

Several operating companies furnished to the author as complete information as they could collect on fires in their mines. Their assistance, which makes this paper possible, is gratefully acknowledged. The list of fires given in Bureau of Mines Technical Paper 59, "Mine Fires in Lake Superior Iron Mines," by Edwin Higgins, was used to supplement information obtained on earlier fires.

Early Fires of the Lake Superior District.

In the following lists of fires only those caused by ignition of timber or other mining supplies are considered. The "black slate" or "sulphur" fires are treated separately further on. Forty fires occurring before 1917 are briefly summarized here.

Summary of 40 Fires Occurring Before 1917.

Place of Ignition		Probable Cause		How Fought	
Shaft	9	Candle	16	Burned Out	7
Shaft or Pump Station	13	Oil Lamps	4	Sealed	11
Shaft House	2	Carbide Lamp	1	Sealed and Water	2
Drift or Crosscut	5	Open Fire	1	Sealed and Steam	1
Sub-level	1	Oil Stove	1	Flooded	1
Stope	3	Power Torch	1	Water	11
Ore Chute	1	Sparks (surface)	3	Chemicals	2
Mule Barn	2	Electricity	2	Snow	1
Magazine	3	Lightning	1	Caved	1
Surface Cave	1	Spontaneous	1	Unknown	3
		Hot Ashes	1		
		Smoking	2		
		Friction	1		
		Unknown	5		

The foregoing summary shows that formerly the shafts and the stations opening from the shafts were the danger points; 22 of the 40 fires originated in such places, and two other fires which started in wooden headworks ignited the shaft. The mule barn has been eliminated from among the other points of origin. Candles and oil-burning lamps were formerly the chief sources of ignition, and in this list they account for just half the fires; these causes have also been eliminated in our present day mines.

The older methods of fire fighting are interesting in comparison with the more recent methods. Seven of the early fires were allowed to burn out. Eleven were sealed and allowed to smother; in most of these cases the entire mine was sealed for several days or weeks while the fire died out. According to the records, oxygen breathing apparatus was worn at only two of the fires, and chemical fire extinguishers were used at only two.

Twenty-three lives were lost in the forty fires. One of the victims was a rescue man wearing an early type of oxygen breathing apparatus. The other men were suffocated by fire gases. There is no record of any man being actually burned. Most of the men lost were in parts of the mine distant from the fire.

Recent Fires of the District.

The first group of recent fires covers the period of many changes in the Lake Superior mines. Candles and oil lamps were discarded, and carbide lamps were universally adopted; electric trolley haulage supplanted the mules, and electricity for many purposes was introduced; fireproofing of shafts, shaft stations, and surface structures, using steel, concrete, and "gunite" became the general practice for new construction; and fire fighting equipment, including oxygen breathing apparatus, was rather widely installed in the district. These changes are all apparent in a study of the fires of the second group, which comprises the fires of the last 12 years—1917-28.

The 55 fires summarized below are those concerning which definite information was obtained. All of the serious fires are included, as well as many that were discovered and extinguished before gaining headway, but the list is known to be incomplete. A few fires that caused much damage are omitted because definite information as to cause is lacking, and many small ones are not listed because no record of them was kept. The list is large enough to show the principal causes of the fires and to allow the drawing of some conclusions about them.

Of the 55 fires, 11 caused a considerable loss of property, and seven interrupted operations in shafts. Two lives were lost. Eight other fires interrupted operations for a day or more. The other fires were discovered and extinguished before getting out of control.

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Summary of 55 Fires from 1917-28.

Place of Ignition		Probable Cause		How Fought	
Shaft	10	Electricity	22	Seals Only	3
Shaft or Pump Station	6	Carbide Lamps	5	Seals and Water	9
Drift or Crosscut	20	Paper Torch	5	Seals, Water and Chemicals	2
Sub-level	6	Open Fire	2	Seals and Chemicals	3
Stope	2	Smoking	6	Seals and Steam	1
Ore Chute	5	Oxyacetylene Torch	2	Water	20
Ore Pocket	2	Friction	4	Chemicals	12
Raise	1	Slaked Carbide	1	Ore	2
Explosives Magazine	1	Spontaneous	1	Chopped Out	1
Surface Structures	2	Lightning	1	Flooding	1
		Unknown	6	Not Given	1

Protection Used by Fire Fighters.

Oxygen breathing apparatus	21
All-Service gas masks	4
Apparatus and masks	2
None	28

Summary of Fires by Ranges and States.

Range		States	
Vermillion	3	Minnesota	23
Mesabi	14	Wisconsin	3
Cuyuna	6	Michigan	29
Gogebic	16		
Minominee	2		
Marquette	6		
Copper Country	8		

Summary of Fires by Place and Cause.

Place of Origin	Electricity	Smoking	Carbide Light	Torch	Friction	Other	Unknown
Shaft	4	2	..	..	4	..	..
Stations	3	..	..	..	..	3	..
Drift or Crosscut	11	2	3	..	..	1	3
Stope	1	..	..	1	..	..	..
Sub-level	1	2	1	..	..	..	2
Ore Chute	..	..	..	4	..	1	..
Ore Pocket	..	..	..	..	..	2	..
Raise	1	..	..	..	..	..	..
Magazine	..	..	1	..	..	..	..
Shaft House	1	..	..	..	..	..	1
	22	6	5	5	4	7	6

Electricity predominates as a cause of fire in mines, as the foregoing summary shows. The 22 electrical fires noted have occurred since 1921, and eight of them since the first of this year, thus showing an increase coincident with the extended use of electricity underground. Since electrical fires form such an important group, they will be discussed more fully than the other classes of recent fires.

In looking for the particular electrical equipment that caused ignition, it was found that fires were attributable to:

1. Main power circuits..... 3
2. Trolley or lighting circuits..... 10
3. Motor feed circuits..... 3
4. Signal circuits 2
5. Other electrical equipment..... 4

1. Two of the main power circuit failures were caused by caving and movement of the ground. The third fire burned all evidence of its first cause.

2. Of the trolley and lighting circuit fires, two were caused by wiring improperly installed by others than the electricians; two were caused by crushing the timber caps against the trolley; one by leaving the trolley pole on the wire at the end of the shift so that the wire was held against a timber cap; two by failure of insulators; one by a spark from the trolley wheel when passing a frog, igniting dry lagging; one from an electric light in contact with flammable material in a closed box; and of one the cause is unknown.

3. The motor feed circuit fires were caused by crushing of the timber.

4. Both of the signal circuit fires were due to broken insulation on the signal wires.

5. One fan motor, set close to a post, heated it sufficiently to ignite the wood. The motor of a sinking hoist was left running and set fire to the timber foundation. The resistance coil for an electric tugger heated and ignited the post on which it was hung; the controller was probably left "on" by the miner. Evidence was destroyed in the fourth case where a small transformer and resistance box burned.

Probably the most interesting of the electrical fires on record are five which were ignited by a 250-volt D.C. circuit in contact with timber.

A very unusual happening on one of the main power circuits was the parting of the connection in a junction box just enough to cause the box to heat and ignite the supporting timber. A slight ground movement placed sufficient strain on the cable to cause the parting.

Information at hand shows that six electrical fires resulted from carelessness of employees—failure to shut off power from motors or throw sectionalizing switches, the installation of electrical wiring by unskilled men, and other violations of established rules. Improper methods of installing equipment or improper equipment resulted in three electrical fires. Failure of supposedly standard equipment caused three fires, and caving of ground caused six fires. Nine electrical fires occurred during a regular working shift, and eleven of them started during an off-shift period. Most of the last group were discovered by repair crews or pumpmen.

Of the five fires started by the miners' carbide lights, three were started in old crosscuts or raises by timbermen who were hiding their tools at the end

of the shift. Each of these three fires gained considerable headway before they were discovered. Another fire of this group was started at the end of the shift, when a carbide lamp ignited a piece of canvas fan tubing. The fifth fire was started during the shift by contact of a lamp with drift timbers, and was discovered and extinguished by the mine foreman on his rounds.

Lighted paper torches thrown into ore chutes to estimate the amount of ore caused five fires, which gained such headway that it was a real job to extinguish them. Oxygen breathing apparatus was used at three of these fires, which interrupted production for one or more days on account of gas.

Of the six fires caused by smoking, two occurred in shafts; one caused a considerable damage to property and closed the mine for several days, but the other was quickly discovered and extinguished. Two other fires of the six occurred in main drifts; both of these were out of control when reached and caused large damage to property. The last two fires started in sub-levels, and whereas they did not cause very great property damage, both interrupted operations at the mines.

The four fires attributed to friction were all in inclined, timber-lined shafts, and were charged to overheated shaft rollers. Two of these fires resulted in large property losses.

Two fires that should be given careful consideration were caused by oxyacetylene cutting torches. This equipment is now used underground in many places for repair work, both in shafts and chutes and in ore pockets. Timber covered with metal is apt to have decayed spots that will readily ignite from the intense heat of the oxyacetylene flame and will smoulder for a considerable time before the fire becomes really active. The smoke which naturally accompanies this kind of work may mask the wood smoke until the crew has gone. One of these fires started in an ore raise and the other in a shaft pocket; they were not discovered until some time after the repair men had finished and gone.

Another unusual fire was that started by the chemical action of moisture on calcium carbide. In this case metal cans were provided at the underground stations to receive spent carbide. As the miners emptied their lamps before going to the surface, evidently much unused carbide was also dumped. Near the end of the shift about 200 pounds of this waste material was dumped into the shaft pocket and two or three cars of ore were dumped on top of it. Ignition of the timber lining resulted. Fortunately the fire was discovered before the men were all hoisted. Even though the fire was buried under the ore it would soon have gained headway.

Lightning started a fire by striking the cables leading to the electric pump. The high voltage burnt out the control in the underground pump room and set fire to the wooden panel and supporting timbers. The starting of fires by lightning is very unusual. One fire started spontaneously in oily waste

placed behind a wooden post in a timbered pump room. Two fires started from small open fires, one for warming a pump room and the other for heating waterproofing paint.

Fire Prevention at the Mines.

Much good work in fire prevention has been done by some of the companies, but it can only be outlined here. The fire prevention work has resulted in a smaller number of fires in shafts and shaft stations, in a decrease in the percentage of serious fires, and, perhaps the most striking result of all, in a marked decrease in loss of life.

Fireproofing.

Some of the factors involved in fireproofing a mine are:

1. The use of steel sets—steel sets with concrete lath and re-enforced concrete for shaft construction.
2. The installation of sprinkling systems in timbered shafts.
3. The use of "gunite" to fireproof shaft timber.
4. The use of steel, concrete, and gunite in shaft and pump stations and in explosive magazines.
5. The installation of steel sets in drifts as fire breaks, or the removal of timber and guniting of sections of rock drift.
6. Experiments with fire retarding timber preservatives for drift timbers.
7. Installation of special water lines for fire fighting in drifts and sub-levels; placing special fire hydrants or regular drilling lines; interconnecting water and air pipe lines; installing a special series of water tanks at shaft stations in deep mines to regulate pressure; providing adequate fire hose at underground stations.
8. General use of soda-acid and carbon-tetrachloride fire extinguishers at surface and underground stations.
9. The installation of special fire doors to sectionalize the mine.
10. The use of covered metal containers for oily waste, spent carbide, litter from explosives magazines, and other small flammable materials.
11. Limiting supplies of oil, etc., underground.
12. Keeping the entire mine free from accumulations of rubbish, especially the magazines and stations.
13. Maintaining fire patrols in the mine between working shifts.
14. Adopting very rigid specifications for electrical supplies and installations.
15. Prohibiting or limiting smoking underground.
16. Providing a quick method of fire warning by stenches and mine telephones.
17. Maintaining mine-rescue stations and trained men.
18. Making special studies of fire hazards and having prearranged plans for emergencies, with definite organization, outlined instructions, and fire maps.

The foregoing list briefly covers the fire prevention work upon which a great deal of thought and money have been expended. Some mines still have done very little toward fire prevention, but others have done everything listed above, and more. Fires that occurred in mines that were fully prepared for prevention have been extinguished with little loss of property and small risk to the fire fighters. Time does not permit a detailed discussion of all these preventive measures, but a few will be enlarged upon.

Disposal of Rubbish.

The boxes, paper, and sawdust that go into the mines with blasting supplies constitute the largest source of very flammable waste material that must be disposed of. Investigation shows that most of the mines hoist the sawdust and paper and dispose of it on the surface. About 75 per cent of the mines also hoist all explosive boxes and fuse cases shortly after they are emptied. Some of the top-slice mines break up the boxes, make the pieces into bundles, and place them in a room just before blasting; they thus become part of the mat. In a few mines the boxes are left underground, where they are subject to ignition.

Metal containers are commonly used for oily rags and waste and for fine refuse from the magazines. Some companies provide metal cans at the shaft stations for spent carbide and for all small litter, so that there is no chance for such material to accumulate underground. Less attention is paid to the bark and chips that accumulate at the timber raises, where piles of considerable size may often be found. Old timber from repair work is generally hoisted or placed in the mat; occasionally it is piled in unused crosscuts to decay and become a fire hazard.

Fire Doors.

For the cost involved a good system of fire doors is probably more protection to life and property than any other device. All main shafts at every level and all definite sections of the mine should be provided with doors so that they can be quickly shut off from the rest of the mine.

When there is a serious hazard to a shaft the doors can be mechanically closed from the surface or various underground points. The Lake Superior district has fire doors of many types and of varied construction. There are concrete frames with steel doors, wooden doors protected with metal or gunite, and doors of unprotected wood. Although the fireproof construction is the most desirable, wooden doors will do good service until the fire reaches them.

Mine-Rescue Stations.

With one notable exception, each mining district in the Lake Superior region is well provided with special mine-rescue apparatus and trained men. The various mining companies maintain in their mine-rescue stations 220 sets of two-hour type oxygen breathing apparatus and 65 All-Service gas masks. Bureau of Mines Car No. 8 carries 16 sets of oxygen breathing apparatus and five All-Service masks. In addition to these masks some companies have gas masks that are not considered as part of the mine-rescue equipment, and most of the local fire departments have equipment that is available in emergencies, so that the total number of masks is well above 300 sets.

Most of the large companies and a few of the smaller ones maintain mine-rescue stations, employ their own instructor, who carries on the training work regularly, and have a regular crew of trained men. A few companies are still

wholly dependent upon their neighbors in case of fire. Also some mines are dependent upon their own company stations, which are located at a considerable distance. The company-owned apparatus is located as follows:

	Sets
Vermillion Range	20
Mesabi Range	50
Cuyuna Range	..
Gogebic Range	65
Menominee Range	54
Marquette Range	35
Copper Country	61
Total	285

The mine-rescue telephone, for use in fighting underground fires, was developed in the district and has been adopted by three companies as regular fire fighting equipment. It has been used at three fires and each time has simplified and made safer the work of the apparatus men.

The Lake Superior mines were among the pioneers in the use of oxygen breathing apparatus; the first equipment was purchased in 1911. As improved equipment has been devised it has been adopted, so that the rescue stations contain modern types of apparatus, All-Service masks, self-rescuer masks, the latest gas-detecting device, and supplies that have been proved of value in mine-fire work.

Mine-Rescue Training.

Training in the wearing of oxygen-breathing apparatus and All-Service masks, and in the rudiments of mine-fire fighting is still generally called "rescue training," as the possible saving of life is its first consideration. Mining companies take much interest in training work. It is believed that there is not an underground mine in the district without men trained in the use of breathing apparatus. Twenty-five company employees spend a part of their time keeping the equipment in shape and carrying on the training of the men. The Bureau of Mines instructors are kept busy with requests for training; they reach each mine in the district every second year. The exact number of men who have received training is not known. Over one thousand men have been trained in this work by the Bureau of Mines during the last three years, but they are only a part of the trained men in the district. The men are taught the construction and functioning of the oxygen breathing apparatus, All-Service masks, and "self-rescuer" type of carbon monoxide mask, are required to wear the protective devices in smoke and gas until they have confidence in them, are given instruction in the effects of fire gases, and are taken underground and taught the elements of mine-fire fighting. They are taught, especially, the limitations of the different types of protection, and how to take care of themselves and their team-mates in any emergency. Every rescue man knows how to administer artificial respiration.

As a result of the rescue training, men wore respiratory protection at 27 of the recent fires, and there were no serious accidents. In a few cases work was done in atmospheres that would have been quickly fatal to unprotected men, and at great distances from fresh air.

Many of the operating officials and engineers are qualified mine-rescue men and have also taken the special course in fire fighting work given by the Bureau of Mines, which teaches organization and procedure, gas sampling and analysis, control of ventilation, and other details of fire fighting.

Results of Fire Prevention Work.

With changes in the causes of ignition it is difficult to estimate just what effect the fire prevention work has had on the number of ignitions. Taken at their face value the figures given in the two summaries of fires show that fireproofing work done in the shafts and in the shaft and pump stations has prevented a number of fires. Nine of the earlier fires, or 23 per cent, started in shafts, and 13, or 32 per cent, in shaft or pump stations—a total of 22 out of 40 fires, or 55 per cent, that started in such places. Attention to fireproofing and protecting these exposures started during the first period; the work is far from completed now, since 16 of the late fires had their beginnings in shaft or station. Ten fires out of 55, or 18 per cent, started in the shafts, and six, or 11 per cent, in shaft or pump stations—a total of 16, or 29 per cent; this class of fires has been reduced almost one-half according to these figures. The reduction of fires starting in underground stations is particularly notable and can be attributed both to fireproofing and to the care and removal of rubbish.

Property loss and probable loss of life certainly have been prevented by fire fighting equipment and trained men. One-half of the earlier fires were either allowed to burn out or the mine was sealed to smother them and no further work done. Other fires were fought at great risk to the men. At only two of these earlier fires was oxygen breathing apparatus used. Twenty-seven of the recent fires were fought by men wearing apparatus or masks. The increased use of chemical fire extinguishers is also very marked; 12 fires were extinguished by them alone; they were used five times in conjunction with other methods. The use of brattices or bulkheads to seal off fires has not decreased, but the method of use has changed. If the fire is beyond direct fighting, the tendency is to employ temporary seals to isolate a small part of the mine and thus smother the fire, rather than to seal the entire mine. This procedure greatly simplifies the work and reduces the property loss. Fire and ventilation doors, where installed, speed up the work of sealing. At several fires mechanical ventilation under control greatly helped the fire fighters. Much of this work would be impossible without trained crews equipped to fight fires in gas and smoke. Without doubt many recent fires which resulted in insignificant losses would quickly have reached disaster class had they started 20 years ago. Where some vital part of the fire protection had been

neglected, some of the recent fires caused a considerable property loss.

The employment of fire patrol men in the Lake Superior district is limited to a few companies, and has only recently been taken up. Three of the fires listed in the summary were discovered and extinguished by patrolmen. That such men could be employed to advantage at more properties is indicated by the fact that 29 out of the 55 fires either started or gained headway between regular working shifts. Many of the fires were detected by pumpmen or repair crews working in a distant part of the mine or by men on the surface; some were discovered only when the next shift went to work. A few of the fires had become serious before they were reached.

Special Dangers.

The great danger to life in most metal-mine fires is from fire gases—particularly from carbon monoxide. There is always danger that workmen will be trapped by gas before they can be warned. Very few men have been injured directly by the fire, but carbon monoxide has caused the loss of many lives in remote parts of the mine. Where the ventilation is natural it is almost impossible to predict the course of the fire gases, and changes due to the progress of the fire or to local caves may occur at any minute.

To minimize danger there should be methods of quickly warning everyone in the mine; fire doors that divide the mine into as small sections as feasible should be installed; a plainly marked second exit should be provided; and, in particularly hazardous places, a supply of self-rescuer type masks to protect the men while coming out should be available. Mechanical ventilation under control is of the greatest benefit in both rescue and fire fighting work; where it is not used, crews unprotected by oxygen breathing apparatus or All-Service gas masks should work cautiously, lest they be cut off from fresh air by an inflow of gas behind them.

Formation of Carbon Monoxide.

Carbon monoxide (CO) is usually defined as a product of incomplete combustion, since it is a combination of one atom each of carbon and oxygen. Much of the literature gives the impression that carbon monoxide is formed mainly after a fire is sealed and deprived of the oxygen necessary for combustion. This is not necessarily true. The following facts on the formation of this gas are taken from a review of many articles:

Carbon monoxide may be distilled from wood by heat below the ignition temperature.

Carbon monoxide in dangerous quantities is produced by slow smouldering fires.

Normally, the hotter the fire the greater is the percentage of CO in the gases. CO has been formed so rapidly under such a condition that men have been overcome almost instantly in their working places.

Timber is approximately 50 per cent carbon, and this carbon is the source of most of the carbon monoxide (CO) and carbon dioxide (CO_2) in the fire gases in metal mines. Computations of the ratio between these two gases produced by burning pure carbon at different temperatures were made by Dr. W. Rees (*Coal Age,* December, 1926). The results as shown in the graph accompanying this article are approximately:

Temperature, ° F.	Parts CO_2	Parts CO
800	100	1
900	25	1
1,000	10	1
1,200	1	1
1,400	1	10

It can readily be seen that a hot, quick-burning fire is much more dangerous than a slower one.* The higher the temperatures, also, the greater the expansion of the gases, and the more rapidly they will fill the mine workings.

All kinds of timber in the same physical state will ignite at about the same temperature. Experiments showed that on exposure to a temperature of 375° C. (657° F.) all specimens ignited in less than two minutes. The heat of an acetylene flame is given as 1871° C. (3400° F.), which is more than sufficient for essentially instant ignition. Quick-burning fires, especially in shafts or raises, produce intense heat. In one fire area that had been sealed, temperatures of 1200° F. were recorded. At another place copper ore was smelted.

The possibility of high carbon monoxide from a fire has been shown, but actual samples taken of the return air are usually below 1 per cent CO, and the writer has never found it above that figure at an unsealed metal-mine fire.

When a fire is first sealed the oxygen content in the sealed area rapidly drops, and there is a rise in both CO and CO_2. Deprived of its oxygen the fire slowly dies. Active combustion stops at about 16 per cent oxygen, and standing timber quickly cools below the ignition temperature. Timber that is buried under caves or piles of decaying timber, where the heat is not readily dissipated, will smoulder in air with a much lower O_2 content, ready to flare up on the admission of fresh air. As long as there is combustion CO will form, and probably will continue to form in small quantities after active burning ceases, but at the fire cools the CO decreases in concentration. Although it is not known just when or how this gas disappears, it is safe to say that as long as traces of CO are present behind fire seals there is danger of a "flare-up" if air is admitted. The presence of CO has been used as an indicator of an active fire; experience has shown that this is a good danger signal.

*This conclusion should not be applied to ordinary fires in buildings above ground, where a hot, quick-burning fire involves little or no danger of carbon monoxide. In buildings, carbon monoxide in dangerous quantities is feared only where there is a restricted air supply, as in a basement fire. In mines the air supply is limited, thus favoring the formation of carbon monoxide in fires.—Ed.

Black Slate or Sulphur Fires.

The occurrence of carbonaceous slate gives rise to a troublesome condition in a number of mines on the Menominee Range. The slate is structurally weak, apt to cave when exposed, and carries much finely divided pyrite. When the slate is either crushed in place or caved into old workings, the air is admitted to a multitude of the small particles of pyrite. Oxidation goes on rather rapidly, and as the conditions are such that the heat of oxidation cannot be dissipated, it finally reaches a temperature great enough to cause ignition of the pyrite and of the carbon of the slate. The resulting fires produce large quantities of SO_2 from the pyrite, and of CO and CO_2 from the carbon in the slate. On account of their location in old workings, these fires must usually be sealed tightly and kept sealed indefinitely. With the admission of air, as long as there is exposed pyrite to oxidize, there will be a quick recurrence of fire. There is need for further study of these fires, especially of the gases produced by them. There is a possibility that small quantities of H_2S may be formed under certain conditions, as its characteristic odor has been reported. The main thing noticed is the very low oxygen content behind the seals, making the use of oxygen breathing apparatus absolutely necessary if exploration or other work of any kind is to be done there.

In the prevention of these fires two things have been done successfully—a protecting layer of ore has been left over the slate, and the stopes have been filled when completed. Filling of ignited stopes is also being tried. These measures have been successful, but their application to other mines is an economic problem. At least eight mines have experienced one or more of these fires. In each case the fires were bulkheaded by men in apparatus.

Methane Explosions.

The occurrence of explosive gases in metal mines is rare enough to put the miners off their guard, but frequent enough to cause a number of accidents. In some metal mining districts pockets of methane (CH_4) are found in carbonaceous formations. No gas-producing strata are known in the Lake Superior district. There have been a few fatal explosions of methane, and a number of occurrences of it during the unwatering of old mines. There are two possible sources of methane common to the district which should be carefully considered when reopening a mine. The first is the decay of the mine timber in the absence of oxygen; this is probably the source of most of the occurrences. The other is the chance that waters coming into the workings through swamps or muskegs will trap the "marsh gas" or methane, which is formed from the decaying vegetable matter in the swamp, and release it in the old workings.

The probability of finding methane is of sufficient importance to make necessary the careful and continuous testing of the air during unwatering and exploration. There are three appliances now approved for such testing: the

flame safety lamp, the Burrell Methane Indicator, and the Martiensson Methane Indicator. Testing for explosive gases is part of the instruction given by the Bureau of Mines in its advance fire fighting course, and Car No. 8 is equipped with testing apparatus.

When methane is even suspected all sources of ignition, such as open lights, open flame of any type, such for instance as a lighted match and sources of electrical arcs, should be kept out of the mine until the air has been tested.

Spontaneous Ignition.

Since burning is merely the rapid combination of atmospheric oxygen and the carbon, or other element, it is possible for a fire to start without the application of flame or external heat, merely through the rapid combination of these elements. Such fires are not common and can be guarded against. Two conditions are necessary: first, the opportunity for rapid oxidation; second, the retaining of the heat of oxidation. The materials which most readily oxidize are oils, greases, and the volatile hydrocarbons. Of this class of materials, oily waste or rags, sawdust, or other finely divided wood are the most commonly found. If oily waste is so confined that heat from the oxidation of the oils cannot be dissipated rapidly, spontaneous ignition is probable. The one recent fire in the district from spontaneous ignition originated in some oily waste that had been forced behind a post in a poorly ventilated pump room.

Wood alternately wet and dried absorbs a much greater quantity of oxygen than it normally contains and attains a condition where it is much more readily ignited than if kept either wet or dry. The more finely divided the wood is, the greater is the danger from this source. Such material does not have to be subjected to a high temperature to cause it to blaze; at just the proper stage the sudden admission of air may cause sufficiently rapid oxidation to fire the mass. This is of importance where sawdust is used to pack steam lines.

Bacterial action in moist wood that is deprived of proper ventilation may create enough heat through fermentation to gradually char the wood. If oxygen in sufficient quantities is admitted, the mass may be raised to the point of ignition; this applies to sawdust or finely divided wood in old mine workings. The greatest danger from gob fires is found where human or animal excreta are present. Through the decomposition of this matter phosphorus compounds, such as phosphoretted hydrogen are formed, and ignite upon contact with the air.

There is no record of a fire having started spontaneously in the caved top-slice rooms of the district. The highest temperatures that have been found in accessible spots are much below the danger zone. Nevertheless, it is only a reasonable precaution to exclude from the timber mat all materials that will increase the fire hazard.

Fire-Fighting Plans.

Important steps in protecting a mine are to study it carefully, to face hazards honestly, and to formulate the best possible plans for meeting all emergencies. Such study may lead to the elimination of many dangerous conditions; it will show where fire protection is needed in the way of water, chemical extinguishers, and fire doors. Mapping of the regular air currents will help in planning the safe removal of men and the attack on the fire. Knowledge of the ventilation will also make possible the formulating of plans to be carried out on the discovery of a fire; the closing or opening of doors and manipulation of fans may save both life and property and greatly aid in fighting the fire. The first hour of a fire is the critical time, but there have been many mine fires where nothing was done until several hours had been consumed in confused planning. There are always many decisions that must be made for each fire. Where there is a general plan carefully thought out beforehand, these decisions can receive the undivided attention of the men in charge.

The tendency of many local mine officials to minimize the danger of underground fires is to be regretted. Their indifference causes them to neglect the making of fire plans and also has an unfortunate effect upon the attitude of the men. If the miners are led to believe that the mine is "fireproof" they will have little incentive to be careful in smoking or in the use of open lights. The bosses should frankly explain the dangers of the particular mine to the miners when instructing them as to the various exits to the surface, and should try to obtain their coöperation in preventing fire.

The need of previous organization and planning can only be mentioned here. A number of good papers have been written on the subject. One which covers it concisely and which is especially applicable to the Lake Superior district is "Fire Prevention and Fire Fighting in Metal Mines," by Eaton and Connibear. This paper can be found in the Proceedings of the Lake Superior Mining Institute for 1923, and is recommended to all who have not studied it.

Fire-Resistant Timber.

Experiments in making mining timber fire-resisting, where steel, concrete, or masonry construction is not practical, have proceeded along two lines. Coating timbers with "gunite" has been tried out extensively. The coating of cement makes the ignition of the timber from a local source of heat almost impossible, but experience has proved that it will not prevent the burning of the timber if subjected to a constant high heat. A recent fire started in an unprotected part of a shaft, below "gunited" timbers. The bare timbers were entirely burned out. The "gunited" timbers were burned to some extent for 300 feet above their lower limit, but the cement undoubtedly checked the fire. Only one or two sets of "gunited" station timbers nearest the shaft burned.

The main objection that has been made to "gunite" is that the timber decays beneath it unobserved. "Gunite" is used quite extensively in the Lake Superior mines.

The treatment of timber with fire-resisting chemicals has been advocated, but the practice has been little used in the mines of the Lake Superior district. The burning of timber takes place in two ways: Volatile, combustible gases are driven off by the heat and burn, then the non-volatile parts, such as charcoal, burn. To reduce the tendency to burn, three classes of chemicals can be used: Chemicals which are sublimated and give off non-flammable gases when heated and so dilute the flammable ones; chemicals which lose their water of crystallization when heated and give off non-flammable gases; and chemicals which melt upon heating and form a non-burning protective coating in the wood. Laboratory tests of many chemicals have been made, so that their characteristics are known. None has been found which renders wood incapable of burning, but there are several that can be forced into timber so as to make it difficult to fire and much slower to burn. One of these, borax, has good fire-retarding properties and is an efficient fungicide, so that timbers treated with it are both fire and decay resistant. Experimental timbers treated with the different chemicals have been placed in the Athens Mine near Ishpeming, Mich., for service tests. If the timbers prove satisfactory the use of the chemicals for treating mining timbers should become general.

Recent Fires in Other Districts.

Within the past six months there have been three metal mine fires which caused heavy losses in lives and property. Two of the mines were not provided with mine-rescue equipment or men trained in the use of oxygen breathing apparatus. At the third mine there was only enough equipment for one crew. Much valuable time was lost because no organization scheme had been thought out beforehand. In each case the fire hazard had been greatly underestimated by the men in charge. The habit of failing to recognize the serious possibilities of familiar conditions in the mine is too common in all metal-mining districts. The "fireproof" mine is a rare exception—in fact, is almost non-existent.

The results of the study of mine fires in various parts of the country can be found in the following Bureau of Mines publications: Bulletin 188, Lessons from the Granite Mountain Fire; Technical Paper 24, Mine Fires, a Preliminary Study; Technical Paper 314, Metal-Mine Fires; and Bulletin 229, Fifty-nine Coal Mine Fires.

Results of Mine Fires.

The results of mine fires are often more serious than appear at a casual glance. The direct costs of fighting the fire and reclaiming the mine are high. Once a fire gets beyond direct control the expense mounts rapidly. Such a fire in a drift seldom costs less than $10,000 and frequently exceeds $50,000. Fires

in timbered shafts cost more and are more apt to disrupt production for long periods; they seldom cost less than $50,000, and a few have reached the million-dollar class. Even though there is no loss of life, the expense of reopening the burned area is a serious thing for the company. The employees and the community suffer generally through the enforced unemployment of a large part of the men.

Serious loss of life at mine fires always results in undesirable publicity, political investigations and attempts at regulatory laws, and strained relations with the workmen, affecting not only the mine which suffers the loss, but the entire industry in the section and state. For these reasons every effort should be made to promote among both mine operators and miners a sentiment that would deter any company from operating under conditions permitting of disaster.

Summary.

The circumstances attending fires which have recently occurred compel the conclusion that the mines of the district contain serious fire hazards. However, much good fire prevention work has been done, the results of which are seen in the decrease in fires in shafts and stations through fireproofing. The tendency in new construction is toward fire-resistive structures. Some mines have done practically all that is possible in the way of providing fire fighting equipment, trained men, building fire doors, installing stench warnings, keeping the mine clean, and formulating fire fighting plans. The protected class of mines is becoming larger each year, but there are still a few which are unprotected and have grave fire hazards.

The results obtained by the trained fire fighting crews called upon to use oxygen breathing apparatus have been very gratifying and have greatly reduced property losses. The district generally is well provided with apparatus and men. Recent loss of life has been very small.

Electricity has been shown to be by far the most frequent cause of ignition. The common belief that a trolley circuit will not start a fire has been disproved. The number of mine fires in which every type of electrical equipment has been involved as a cause demonstrates the need of carefully installing and inspecting electrical equipment.

The number of fires which have started between regular working shifts shows the value of fire patrols during the time when no work is being done.

A survey of fire hazards and a detailed plan of fire fighting in each mine are recommended.

Probably the most essential factor in the handling of a mine fire is mechanical control of ventilation; hence every mine, metal as well as coal, should have a mechanically operated fan and a well-systematized coursing and control of air currents.

Sawmill Fire at Skykomish, Washington.

Report by Washington Surveying and Rating Bureau,
(Member N.F.P.A.)

The Bloedel-Donovan Lumber Mill at Skykomish, Washington, was partially destroyed by fire on July 26, 1928, with a loss of over $50,000. The fire, starting in the boiler house, spread rapidly and before it could be brought under control destroyed a recently erected fuel vault and seriously damaged more than half of the sawmill building.

The group of buildings involved in the fire were located on the edge of the log pond about fifty feet away from the adjacent planing mill and lumber dry kilns. They represented about one-third of the sawmill group and included fuel vault, boiler house, generator room, engine room and log end of mill up to edger and gang saw, and including the filing room in the roof space of the mill. The buildings were of light frame construction and said to be in poor to fair condition. The boiler house, fuel vault and engine room had corrugated iron roofs, the generator room a wood sheathing roof, and the sawmill a roof of wood and composition roofing material.

The mill and boiler house were equipped with a system of automatic sprinklers graded as sub-standard. The system was dry-pipe, but it was cus-

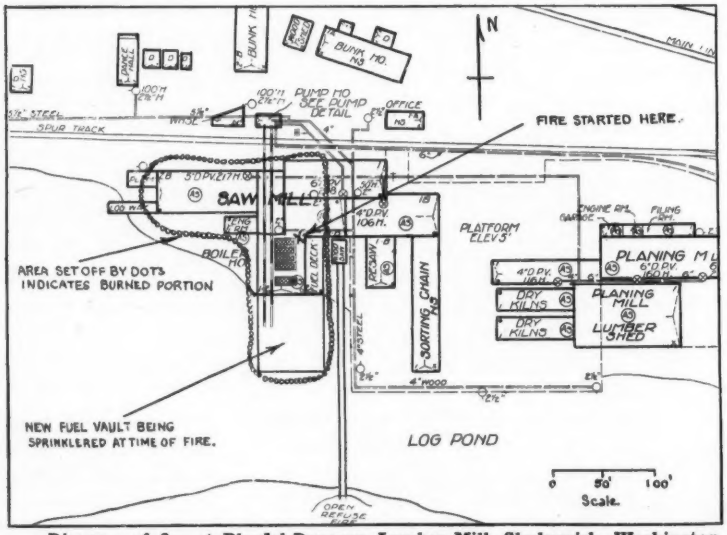

Diagram of fire at Bloedel-Donovan Lumber Mill, Skykomish, Washington, July 26, 1928.

Mill—looking toward boiler house, showing character of roof and general construction.

tomary to maintain all dry systems wet-pipe during summer months. The sprinklers in the boiler house had been shut off in connection with the extension of the system to the new fuel vault. This was undoubtedly the cause of the fire gaining such headway as it did during its early stages. The sprinklers in the mill building operated promptly and credit must be given them for retarding the spread of the fire in the sawmill sufficiently to allow the fire fighters to get hose lines into play, even though they did not prevent the fire from destroying part of the building.

The water supply for fire purposes was from two sources. The primary supply was a 6-inch connection to town water mains with approximately 146 pounds static pressure, 1,000 feet of 6-inch pipe to next larger main. The secondary supply was from one 500-gallon per minute fire pump and one ordinary pump. The steam supply to the pumps was considered adequate.

There were eighteen sub-standard standpipe hydrants about the plant, supplied through 4, 5½ and 6-inch mains from pumps and city connection. The hydrants were in frost-proof boxing in valve houses with 100 feet of 2½-inch hose attached with nozzle.

The day of the fire was warm and dry, with a light southerly wind. The fire started, as near as can be ascertained, about 6:30 P.M. Except for two millwrights working in the sawmill and the fireman in the boiler house the buildings were unoccupied. The fireman, who was cleaning out the boilers, had completed one and was shoveling fuel into another, when he looked up and it seemed to him that the entire boiler house was ablaze. He grasped the whistle cord to sound the alarm, and on the third tug the cord burned through. The fire had then become so intense that he had to leave.

Log deck looking into mill. This picture indicates the intensity of the fire.

Ruins showing complete destruction of west wing of sawmill, boiler house and fuel vault.

Fifteen or twenty men were assembled in a recreation building across the tracks about one hundred and fifty feet from the mill. When the whistle blew they ran out, and by the time they reached the fire flames were shooting out of the log end of the mill. Various people interviewed stated that there were three distinct explosions, which in all probability were caused by the ignition of wood dust and were a factor of the rapid spread of the fire.

Showing stop of fire in mill. A good water supply and intelligent fire fighting upon the part of the mill fire brigade resulted in stopping the fire at this point and saving the major portion of the property.

The plant fire chief arrived at the scene of the fire in about five minutes from the sounding of the alarm and immediately started up the pumps. It was soon noticed, however, that the steam pressure was dropping rapidly and it was subsequently found that a steam main had been broken by a falling timber. With the pumps out of commission, hose streams were supplied by the city connection.

About a dozen hose streams, together with the sprinklers which had opened up, were in operation at this time and the pressure dropped to about 20 pounds. The sprinklers and all but six of the hose streams were shut off and water barrels and buckets were used in the rest of the plant to extinguish fires from flying brands, which had ignited some of the structures directly to windward.

The fire chief's objective was to keep the fire from involving the entire sawmill building and, in spite of the fact that the wind was against him, he succeeded. Five streams were concentrated on the mill, while one additional stream was used to protect the miscellaneous buildings across the track. It is stated that a residual pressure of 75 pounds was maintained during the fire, indicating that the water pressure and supply from the city mains was adequate. This, undoubtedly, was a large factor in bringing the fire under control.

This fire brings out the handicap put on any sprinkler system where portions of buildings or groups of buildings are not protected by the system, and clearly emphasizes the need of extra care and precaution during periods when

all or a portion of a sprinkler system is out of service for any reason. It also emphasizes the value of an adequate dual water supply, particularly where the boilers were located in a combustible building and steam pipes were inadequately protected, thus cutting off the supply of steam to fire pumps and rendering them useless.

The accompanying illustrations and diagram show plainly the intensity of the fire, and indicate the effective work of the fire fighters in a situation where a public fire department was not available and reliance had to be placed entirely on a private fire brigade.

Lawrenceville, Ill., Oil Refinery Fire.

By Paul Truesdell,

National Petroleum News.

A tongue of flame flashed out of the open manhole of a steam-filled rerun still at the plant of the Indian Refining Co., at Lawrenceville, Ill., leaped 100 feet across the refinery yard and burned 67 men on August 1. Twenty-one were killed and fifteen seriously burned; the others escaped with minor injuries. Property damage was less than $100.

The accident was freakish and cannot be positively accounted for, according to Dr. Frank Fritts, executive vice-president of the company. Plant rules were followed to the letter in the handling of the still previous to the blast. There was no deviation from methods that have been used in the operation of stills hundreds of times in this plant. The explosion followed a small fire, similar to those that occur in every refinery from time to time, and the fire had been extinguished before the explosion occurred. Thoroughly experienced men were on the job.

The still from which the searing blast came was one of a battery of 12 rerun stills, combination fire and steam. The stills are fired interchangeably with waste gases from plant operations and fuel oil, and have conventional steam spiders in the bottom. Ten of the stills are of 750 barrels capacity each and two are 1000-barrel stills. The battery is used for rerunning cracked distillate from the Dubbs and Cross cracking units. The Cross battery consists of seven 1000-barrel a day units and one 2000-barrel unit. The Dubbs plant consists of four 500-barrel a day units. The cracked distillate before rerunning averages about 96 initial and 440 to 445 end point.

The rerun battery is run batch. In fact, it is merely a row of stills and not a battery because the stills are run individually and not in series. Each of the 750-barrel stills is equipped with a small hollow knock-back tower, and each of the 1000-barrel stills has a modern bubble tower.

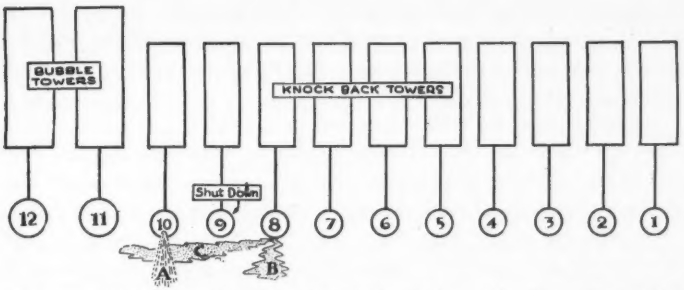

Diagram of the rerun battery at the Indian Refining Co. Plant No. 10 is the still in which the explosion occurred. A shows the blast coming from the manhole in the end of the still, B the flaming stream of oil that caused the turning in of a fire alarm, and C the secondary stream, the heat from which is thought to have vaporized a small amount of pressure distillate in the steam-filled No. 10 still and caused the explosion.

Each of the smaller stills, in starting up, is charged with about 500 barrels of pressure distillate and is run down to 400 end point, the tower condensing the heavier ends of the vapors and refluxing them back into the still. When the stream in the tailhouse shows 400 end point, the still is shut down and the bottoms are pumped into one of the two 1000-barrel stills.

The bottoms from the smaller stills are run down in the big stills and the vapors fractionated in the bubble towers, the stream passing overhead from the bubble towers being a 437-end point gasoline. The bottoms from this distillation are collected, rerun to remove excessive sulphur, and then blended into the charging stock for the Cross cracking units.

As shown in the accompanying line drawing, the stills in the battery are numbered from the right, the two 1000-barrel stills on the extreme left end being 11 and 12. Here is the story in sequence as it was told me by Dr. Fritts and developed at the coroner's inquest. I had gone to the plant to try and learn the cause of the disaster and to see whether it offered any lessons which refinery operating men generally might use to prevent other similar tragedies.

About 7 o'clock, Tuesday night, July 31, Pearly Wells, refinery superintendent, noticed that No. 10 still in the battery had sprung a leak and oil in a stream the size of a man's thumb was dropping down into the furnace. He at once gave orders for the fire to be turned off and the still pumped out and steamed, preparatory to cleaning out and patching the fire sheet next day. His orders were followed.

The fire was shut off, the still pumped out and steam turned into it. This is the usual practice at the refinery when a still is shut down. The steam was at about 90 pounds pressure, which means about 300 degrees F. temperature. The still was steamed for about 14½ hours, the steam going overhead through the vapor lines and presumably carrying with it vaporized, volatile parts of what oil remained in the still.

After the steaming period, around midnight, the steam was turned off and the still "blanked off," that is, steel plates bolted into the pumping in and pumping out lines between the flanges to prevent any oil or vapor from getting into the still from outside.

This being done, the stillman, according to regular practice, removed the manhead on top of the still. Steam, of course, came out, and the stillman smelled it for any odor of gasoline. He could detect none. About half an hour later he also took off the plate on the manhole in the front end of the still.

Then the still stood there, steam escaping from the two manholes, waiting for the time when it should cool off enough so that a man could go in, sweep out any heavy ends that might be left on the bottom, scrape off the carbon and make it ready for welding a patch over the leak.

About 4 o'clock in the morning the stillman discovered that No. 8 still had sprung a leak (No. 9, between 8 and 10, was shut down). Oil escaped from this leak faster than it could be burned in the furnace and it ran in a flaming stream down across the yard in front of the battery. There was no particularly great danger in this because there was nothing much in the way of the stream, but the stillman at once turned in a fire alarm.

The entire plant fire brigade, both those men on duty and those who were at home, off duty, responded, together with a number of townspeople, the refinery being the town's leading industry. All together there were close to 100 people, fire fighters and sightseers, in the plant.

The fire brigade started the foam mixer and pumping engine and brought the foam hose to the scene of the fire. The stillman, of course, had previously shut off the fire under No. 8 still and started pumping out its contents. While the fire fighters turned the foam on the main stream of fire, oil continued to leak in driblets from the still, flaming, of course, when it hit the air and made a secondary small stream of fire that ran along diagonally in front of the setting of No. 10 still.

The foam equipment worked perfectly and in 20 or 25 minutes the fire was out. A large group of firemen and sightseers were standing, bunched together, 50 to 100 feet from the front of the still battery, resting from their labors and surveying the scene. Another group was bringing up a second foam hose in case it should be needed.

That was the situation when, at 20 minutes to five, there was a slight puff, not enough noise to make men in other parts of the plant pay any attention to it—and the flame leaped out, scorching the two closely huddled groups of men. It lasted only a fraction of a second. The injured were given first aid by the plant doctor, who called eight other doctors and a number of nurses to his aid. Then they were sent to hospitals.

Dr. Fritts had been out of town and arrived at the office about 8 o'clock on the morning of the accident. He ordered everything possible done for the sufferers.

His theory of the accident is that the burning stream of oil that ran past the setting of No. 10 still from the leak in No. 8 heated up a small pocket of oil that had been left on the bottom sheet of No. 10 sufficiently to vaporize it and, escaping from the manhole, of course, the vapor flashed when it came in contact with the air.

How to prevent such accidents in future?

That is a hard one. Ninety pounds is about as high pressure steam as is usually available in refineries, and 300 degrees F. evidently is not hot enough to vaporize and drive off all the light ends of a 440-end point distillate. Higher pressure steam and consequently higher temperature might do this.

Smelling of the steam is about the only test for gasoline vapors remaining after a still has been steamed, and it is likely that refinery workers' noses become more or less immune to gasoline smell from long familiarity with it.

However, there are two things that Dr. Fritts is doing at the Indian plant that might help to avoid similar accidents in the future in other plants as well. First, he thinks it is important that stills be set so that the bottom slopes considerably toward the opening of the pumping out line, so that the still will be entirely drained by the pump.

He is having all the shell stills in the plant examined with this in view, and those that do not have a sufficient slope will be reset so they do. It is likely that the stills in many plants were set rather hit or miss in this regard. Another thing is to keep depressions out of the still bottoms. If there are even small dents these will tend to collect oil and may furnish the makings for an accident.

Everybody knows the danger of a considerable bag or belly in a still bottom, but it may be that the importance of small depressions in some plants has been overlooked.

Then, too, it is always unsafe for a group of men to bunch together in front of a still battery, particularly when there is or has been a fire in progress.

The Same Old Story.

The fire had burned the livelong night,
The building was demolished quite—
The janitor, when asked the cause,
Cried out without a moment's pause,
"Excelsior!"

—*Yale Record*

New Orleans Alcohol Plant Fire.

Report by Louisiana Rating and Fire Prevention Bureau,
(Member N.F.P.A.)

One man lost his life and property was damaged to the estimated amount of $220,000 in a fire on August 31, 1928, which involved a portion of the alcohol plant of the American Solvents and Chemical Corporation, located in Algiers, a district of New Orleans located across the river from the city proper. The exact cause of the fire is not definitely known, but was apparently due to the ignition of alcohol vapor. The fire spread rapidly from the point of origin and the buildings involved were completely enveloped in flames by the time the first fire companies arrived.

Construction and Protection.

The main building is of brick, ordinary joisted construction, two, three and four stories in height, with composition roof and part wood and part concrete floors. The fermenting building is one high story and adjoins the main building on the south side, and is not cut off. The high wine room and the bonded warehouse are of frame construction and adjoin the fermenting room on the south side, and are partially cut off by a blank brick party wall. However, the wall of the fermenting room extends about 5 feet above the brick wall. The two warehouses in which the fire originated were of frame construction, one story in height, with part concrete and wood floors raised about 36 in. above concrete floor. The smaller warehouse was 42x106 feet and detached 20 feet west of the fermenting room, the other 60x265 feet and detached 85 feet from the fermenting room and 19 feet from the smaller warehouse.

The protection in this plant consists of a one-supply sprinkler system supplied by an 8-inch connection to an 8-inch city main fed two ways and well gridironed to 6 and 8-inch city mains but giving only 12 pounds pressure on the top lines; also watchman reporting to a portable clock. Three 600 G. P. M. pumpers are available on first alarm from the fire department. Four two-way and steamer connection hydrants available within 200 ft., 6 others within 500 ft. Hydrants are on 6 and 8-inch mains supplied by city water works. The sprinkler system mentioned above did not extend to the two warehouses in which fire occurred.

Story of the Fire.

At about 11:15 A.M., the manager of the plant who was in the office of main building heard a small explosion, which was followed by a cry of "Fire" by one of two men who were filling and weighing alcohol in 50-gal. drums in north end of larger warehouse. He immediately ran to warehouse and found

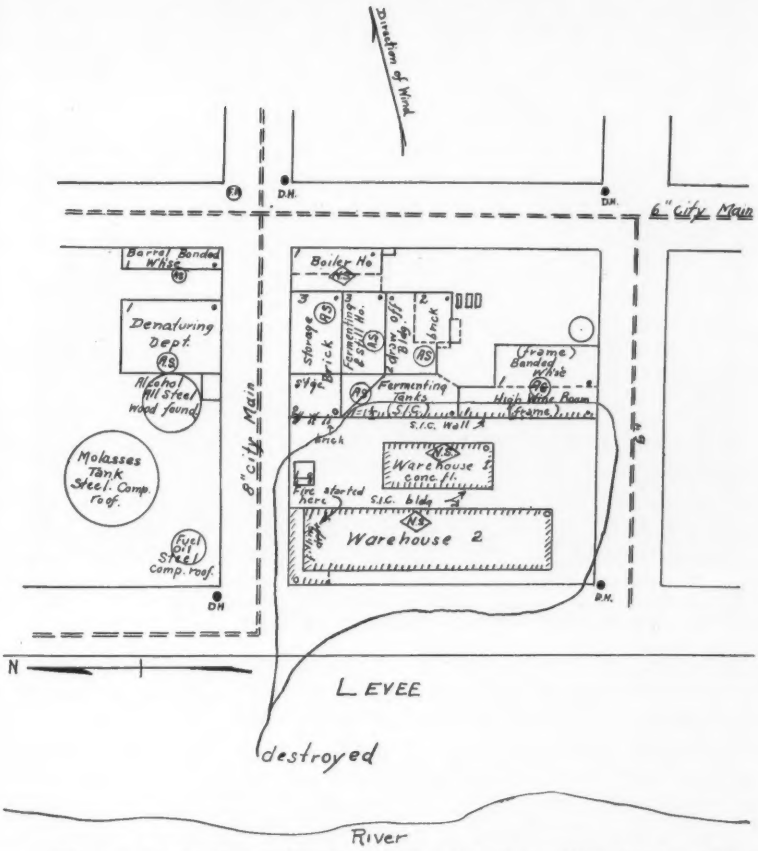

Diagram of American Solvents and Chemical Corporation, showing area destroyed by fire on Aug. 31, 1928. (Not to scale.)

one of the barrels, which had just been inspected and was being filled, was on fire. He attempted to smother fire with a piece of cloth. About this time another barrel caught on fire and while they were rolling it out of the building several apparently empty barrels exploded and all men were forced to leave as the entire building was enveloped with flames. An alarm was sent in from the fire alarm box at corner. The fire department received this alarm at 11:20 A.M., and response was immediate. By the time they had arrived, both buildings were on fire and alcohol drums were exploding with amazing rapidity, sending clouds of fire high into the air and seriously threatening the main group of buildings. The Algiers department, realizing the impossibiltiy of

New Orleans alcohol fire, Aug. 3, 1928, looking toward river. Note burst of alcohol vapor in the air; also frame superstructures on top of still building, which caught fire a half hour after the picture was taken.

coping with the situation alone, at 11:30 A.M. requested aid from the city proper fire department, who responded at once with five pumpers and five chemical engines. This alarm was followed at 11:40 by a general alarm and all available apparatus was sent to the scene of the fire. The fire boats "Deluge" and "Sampson" also arrived at about this time and played water towards the fire, but were too far away to reach it with their monitor nozzles.

A westerly wind sprang up about 11:45 and the flaming vapors were blown toward the main building. At about 12:00 the fire had attained large proportions and the fire department was seriously handicapped by the intense heat and the constant danger of being hit by exploding alcohol barrels which were thrown high in the air by the force of the explosion. There were about 12 pumpers then in operation and from 30 to 40 lines of hose directed on fire and on main building where the frame portions were beginning to catch fire. In addition three lines of hose were run from the fire boat "Deluge" to shore to play on exposed portions of main building. At the start of the fire the manager had instructed employees to knock out fusible portions of sprinkler heads in sections of building exposed to fire and a line of hose was connected to steamer connection of sprinklers to furnish water to sprinklers which were receiving very little water due to enormous draught on water mains by the pumpers.

The fire department directed its efforts to keeping the fire from destroying the main portion of plant and was directing streams of water on the roof and burning walls of the fermenting room and high wine room from behind the fermenting tanks and from the top of the draw-off building. About 1:00 P.M. the frame and frame, iron-clad tank house and superstructures on the roof of the still building caught fire, due to lack of water for sprinklers. (Hose to steamer connection had broken and city water pressure was insufficient to force water to this height). Due also to the difficulty of bringing hose to the roof of this section, the fire gained considerable headway before two hose lines could be directed on it. Fire inspectors, noting that the fire was gaining headway in the above portions and knowing that the sprinklers in this section should have controlled this fire, investigated at once and found that the pumper was no longer supplying sprinklers as one length of hose to steamer connection had burst. It was not known how long this condition had existed, but immediately after the firemen's attention had been called to the impairment of the sprinkler equipment, they connected up a new length of hose, and pumper again put water into the sprinkler system and fire in this section of main building was soon extinguished.

The fire was now being brought under control and danger to the main building and additions was over. The fire burned till about 10:30 P.M., until all the alcohol had been destroyed.

Extent of Loss.

The two warehouses were destroyed, together with about 6,800 fifty-gallon drums of denatured alcohol and whatever equipment was in these buildings. The outside walls and portions of the roof of the fermenting building and the high wine room were destroyed, as well as the window sashes and the water tank on top of the still house and the frame and frame, iron-clad top of still house and portion above storeroom. The fermenting tanks were somewhat damaged as well as the equipment in these buildings. The manufacturing portions of plant (still house and fermenting sections) were not severely damaged, considering the intensity of the heat. The plant was operated the night of the fire long enough to allow the completion of the stock in process, although they were handicapped in this operation due to the loss of their gravity water tanks and the fire damage to one separator. The manager stated that he thought plant could be put in complete operating order in about two weeks from date of fire.

At 5:55 P.M. an exploding drum was thrown about 100 feet into the air and came down on the head of Lieutenant Manuel Vinet of Algiers Engine Co. No. 18, fracturing his skull and probably breaking his neck, causing his death in a hospital the next morning.

Several firemen were also overcome by the intense heat and had to be relieved.

The total loss to buildings and equipment is stated to be approximately $220,000.

Conclusions.

No definite cause could be established for the origin of the fire. However, the rapid spread of the fire was no doubt due to the collection of alcohol vapors in the building, which were doubtless accentuated by atmospheric conditions previous to fire and the lack of ventilation in building. The alcohol vapors in the building were furnished by evaporation of alcohol which may have been spilled on floors during process of filling barrels and from evaporation of small amounts of alcohol in drums about to be filled.

The above condition existing, it only remained for the necessary spark to ignite these vapors and cause the disastrous fire that followed. This spark may have been furnished by any one of a number of means, such as : (a) lighting a cigar or cigarette; (b) static sparks; (c) electrical ground from defective wiring; (d) short circuit across exposed terminals of storage battery.

In discussion of the above causes with the manager of the plant, the inspectors came to the following conclusion:

(a) Manager advised that "No Smoking" rule was rigidly enforced and that the two men working in plant positively stated that they were not smoking.

(b) This cause is very improbable as filling apparatus and drums are grounded.

(c) Only wiring in building was in conduit and to one plug-in receptacle into which was connected one extension light with heavy rubber covered approved portable cord. The light was a carbon type, enclosed and approved by Underwriters' Laboratories for hazardous locations. This wiring was all new and stated to have been in excellent condition.

(d) The last mentioned cause seems the most probable as it was stated that some tools were lying on a drum near storage batteries. It is probable that one of these tools or some other piece of metal, fell across the terminals of the storage battery, causing a spark and igniting the vapors. The storage battery was of the six volt type and was used in connection with an automatic weighing device which cut off flow of alcohol when drums became full.

This fire clearly illustrates the necessity of complete sprinkler installations, especially in buildings of hazardous processes, such as were involved in this fire. Such an installation would doubtless have confined the fire to the point of origin with a very small loss. It also illustrates the importance of the steamer connection as an aid to sprinklers. As mentioned above, although the line to the steamer connection broke at the height of the fire and the fire gained considerable headway before a new length was provided, it was again checked when water under sufficient pressure was supplied to sprinklers. Electrical equipment in buildings with hazardous occupancies should be properly safeguarded.

Fires in Which There Was Loss of Life.

These notes are intended to point out typical conditions under which loss of life has occurred, that they may be known and guarded against.

Automobile Accident.

H-26399. ATLANTIC CITY, N. J., AUGUST 28, 1928. A produce truck driver was burned to death following a collision with a rapid transit bus just outside the city. While the attention of the crowd was focused on the injured in the bus, the melons and squashes in the truck rolled on to and buried the driver of the truck, who could not be extricated when the truck caught fire.

Fire Fighting.

H-26024. PATERSON, N. J., APRIL 27, 1928. Two firemen were killed and twelve were injured when two floors collapsed during a fire which destroyed the interior of a department store. The two deaths occurred when the firemen entered the ground floor of the three-story brick building. The fire was blazing fiercely on all three floors of the building when suddenly the second, and a moment later the third floor, gave way, burying the firemen beneath a mass of débris. Structural defects are believed to have hastened the collapse. A number of the firemen were injured by the falling floors and in the subsequent attempt to rescue their comrades who were pinned beneath the wreckage.

Composition Flooring.

H-26025. DORCHESTER, MASS., APRIL 27, 1928. One man lost his life in a fire which occurred in a warehouse under construction. Workmen were engaged in waterproofing and insulating floors and walls in the basement of the building. Specifications called for two coatings of asphalt over cork, and the asphalt was being pumped into the basement and then sprayed over the floor and walls. While one of the employees was engaged in this work, a bucket of hot asphalt was accidentally tipped over and it set fire to the highly flammable preparation which is used in making the asphalt adhere to the cork. The employee was trapped by the rapid spread of the flames and burned to death.

Flammable Liquids.

S-47305. MALDEN, MASS., APRIL 25, 1928. An employee in a paint and varnish factory was preparing a special shipment of solvent. He was pouring lacquer thinner from a measure into a fifty-gallon drum when the contents of the drum and the can from which he was pouring the liquid ignited, probably from a static spark. The flash and heat from the burning liquid opened eight sprinklers and prevented an explosion of the various drums of flammable liquids in the room. The employee was so badly burned that he died later in the day. Two other employees were slightly burned.

Railroad Accident.

H-26340. GUERNSEY, WYO., JULY 29, 1928. Eight unidentified men were burned to death in a spectacular freight train wreck on the Burlington R. R. The train, for the most part composed of tank cars, was enveloped in flames following its derailment caused by the loosening of the road bed by cloudbursts. The eight men were beating their way in a box car, from which they had no means of escape when the burning gasoline reached the car.

Oil Lamp.

L-289. SPRINGFIELD, MASS., JULY 16, 1928. Two small children were burned to death when their mother dropped a lamp which "exploded" at the foot of a ladder which was the only means of access to the loft where they slept. The mother, rheumatic and unsteady, got up about 4:30 o'clock to attend a fretful baby and dropped the lamp.

Oil Stove Fire.

L-287. OTISVILLE, N. Y., JULY 30, 1928. A 35-year-old invalid, unable to leave her wheel chair, was burned to death in her home. Her husband had been visiting a neighbor and returned to find her in flames. It is believed that her clothing caught fire while she was attempting to light an oil stove.

Children Alone in House.

L-294. JACKSON COUNTY, KY., SEPTEMBER 3, 1928. Four children were burned to death in their home while a small dog's efforts to attract aid were in vain. The parents were in church and no significance was attached to the disturbance the dog was making, and he was ejected each time he entered the church. When the fire was discovered the roof had fallen in and the children had already been burned to death.

Children and Matches.

L-279. CANTON, MASS., JULY 20, 1928. A two and a half year old boy lost his life, during the excitement of a fire, by running back into his home after having been carried to safety by his mother. Children playing with matches are believed to have started the fire.

L-282. HAVERHILL, MASS., AUGUST 15, 1928. While his mother was seriously ill in the hospital, a four-year-old boy left alone in the house received fatal burns. He was playing with matches.

Woman Refused to Jump.

L-273. WASHINGTON, D. C., JUNE 17, 1928. A woman recluse perished in an early morning fire when she refused to jump to safety. When a neighbor discovered the fire, the entire front of the house was in flames. He called to the woman in the window to jump, but she, evidently frightened out of her senses, reeled from the window and ran down stairs into a veritable furnace of flame on the first floor.

Trapped in Burning Building.

L-277. BOULDER, MONT., JULY 14, 1928. A mother and her four small daughters were burned to death in a fire which destroyed their home. Three boys saved their lives by jumping from a window. An oil lamp is believed to have caused the fire.

L-285. NEW ROCHELLE, N. Y., AUGUST 8, 1928. A two-year-old boy was burned to death and his father was seriously injured in trying to save him, when fire swept a bungalow on Clifford Island. The father fought the fire until it was beyond control and then carried his daughter to safety. After he was outside he realized that he had left his son inside. His efforts to rescue the child were futile.

Gasoline and Kerosene.

L-283. PLYMPTON, MASS., JULY 29, 1928. Pouring kerosene on a lighted stove had fatal results for a woman, and her blind husband was severely burned in extinguishing the fire on her clothing. The oil can from which she was pouring the fluid "exploded" and she ran outdoors. All the windows of the kitchen were blown out and the house was set on fire.

L-275. NEWPORT, R. I., AUGUST 16, 1928. A woman was burned to death when a bowl of kerosene which she had taken into the yard for spraying dahlias caught fire. The neighbors put out the fire and took her to the hospital, where she died. A charred box of matches was found on the lawn.

L-286. FARGO, N. D., MAY, 1928. A woman lost her life as a result of burns received when gasoline in which she was cleaning clothes exploded. She was severely burned from her knees to her head but managed to toss the burning clothes into a garbage can on the fire escape. She died in a hospital.

Motor Boat Fire.

H-26253. MURRAY ISLE, ST. LAWRENCE RIVER, JULY 11, 1928. Two women lost their lives and 13 other passengers were badly burned when a mail boat was burned to the water's edge. The boat was a large pleasure craft and caught fire when the motor backfired. All of the passengers crowded to the stern, whence increasing heat soon drove them overboard. Several men were seriously burned trying to snatch life preservers from within the burning launch and fasten them upon the women.

Lightning.

L-292. GRENOBLE, FRANCE, AUGUST 15, 1928. Five villagers were electrocuted when lightning struck a transformer distributing current to three near-by villages. Great sparks flashed in all the houses in the district and six were burned. The inhabitants were panic stricken and four lost their lives trying to cut off the current by breaking the wires with sticks while it was still raining. The fifth victim took hold of a metal pump handle to get water to fight the fire and fell dead.

National Fire Protection Association

INTERNATIONAL

Executive Office: 40 Central St., Boston, Mass.

The National Fire Protection Association was organized in 1895 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the coöperation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes over a hundred national and regional societies and associations and more than four thousand individuals, corporations, and organizations.

The QUARTERLY is one of a large number of publications issued by the Association and sent to the members as published. These include the monthly *News Letter*, standard regulations on fire prevention and fire protection, special reports and bulletins, the Year Book, and the Proceedings of the annual meetings.

Membership in the National Fire Protection Association is open to any Society, Corporation, Firm or Individual interested in the protection of life or property against loss by fire. All the valuable engineering and popular literature issued by the Association is sent, as issued, to every member. The Association is the clearing house for all the authoritative information on Fire Protection and Prevention, and members are privileged to submit to it their individual problems for solution. The Association is always glad to send samples of its publications to prospective members upon request.